An Exploration with Technology Acceptance Modelling into how PSD2 Could Improve User Interactions in Personal Finance

Edward Barber

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Submitted by: Edward Barber

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Declaration

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Abstract

A two-fold study attempting to perceive the possible innovations possible thanks to the upcoming Payment Services Directive II using a newly extended adaptation of the Technology Acceptance Model with an aspect of Social Intention, the SITAM.

The research successfully highlights the legislation's consequential opportunities, and crafts a multi-banking application with price comparison integration with high user intention to install, lending itself to being developed into a full public release in the future. The SITAM meanwhile gives a new approach to planning and developing software to theoretically maximise adoption at every stage of the lifecycle, offering a contemporary method of categorising survey participants into innovation groups in order to treat feedback differently to match the target market.

Keywords: Payment Services Directive II, PSD2, FinTech, Mobile Banking, Adoption Modelling, TAM, IDT, Price Comparison

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Chapter 1

Introduction

The aim of this dissertation is to study the user experience of existing mobile personal banking applications, then to delve into the opportunities presented by the upcoming *Payment Services Directive II* (European Union 2015, hereafter 'PSD2'). In particular this research explores the possibility of creating an alternative personal banking application that can effectively provide ongoing financial advice to users by accumulating account data from a variety of banks to combine with a price comparison provider.

1.1 Problem Description

As the popularity of smartphones and the availability of mobile internet have taken off, so has the focus on and usage of mobile finance applications, with 1 billion people expected to use some form of mobile banking globally in 2017 (Shaikh and Karjaluoto 2015). In the UK, 63.5% of the population now uses online banking (EU-Commission 2015), with the British Banking Association (BBA 2015) reporting that one high-street bank had 65% of their non-branch banking accessed through smartphone apps in March 2015 - double the number of logins in the same month of the previous year.

However, mobile apps thus far have mostly just consisted of a watered-down internet banking experience. Modern consumers are now expecting much more, with a clear unique selling point and personalised offers among aims that the current selection of apps have yet to achieve (Guibaud 2016).

With such huge levels of mobile banking adoption, is there any opportunity to bring a new standard of user interaction to the fore?

1.1.1 PSD2 Legislation

The Directive on Payment Services (PSD I) was created to establish rules on payment services throughout the EU, such that cross-border payments within member states become as *"easy, efficient and secure"* as internal payments (European Union 2007, p.1). However, this original PSD "makes little attempt to address the particular issues which arise in online payments" (Donnelly 2016, p.2), as these mostly arose after its introduction in late 2007. Therefore, a new directive was required to incorporate the newer online payment methods by "tackling some of the legal challenges they trigger" (González Fuster 2016, p.181). The EU then constructed PSD2 and it passed voting in January 2016 for transposition by January 2018 (though a separate timeline exists within the legislation for abiding by certain aspects (Donnelly 2016)).

Of particular interest are the so called 'access to account' XS2A articles found within the PSD2 revision. As explained by Salmony (2014), these will require regulated payment service providers to allow third party providers (TPPs, more in Section 2.1.2) to access and perform actions on customer accounts once they are marked as trusted. This provides a great opportunity as it can reduce the challenging nature of entering the TPP market (Janczuk 2009), potentially improving competition and eventually providing a cheaper and more effective consumer payment environment. There will also be some form of mandatory regulation and associated security standard that TPPs must abide by, though these are currently unspecified.

Although the method of technical implementation is also not currently specified, this will almost certainly result in banks having to create open APIs[1] for use by TPPs in their websites and applications, such as the one that will be created in this study.

1.1.2 Aims and Objectives

Primary Aim

Study the potential innovations that could be created in the wake of PSD2 enforcement, creating suggestions and guidelines for others to take on with the aim of producing industry-disrupting technology to revolutionise the way consumers interact with their personal finances. This will be supported and augmented by the design, creation and evaluation of a system implementing the open APIs of users' banks to consolidate their account data and provide useful financial advice.

[1] Application program interface (API) is a set of routines, protocols, and tools for building software applications (http://www.webopedia.com/TERM/A/API.html)

Objectives

These are the main objectives against which the success of the project will be judged.

1. Research the current state of mobile finance, including the security and ethical implications involved and acknowledge challengers to the status quo such as cryptocurrencies
2. Employ findings to conceptualise a multi-bank price comparison app, carrying out user adoption research using a suitable model to test potential appetite for and trust of the proposed system.
3. Create alternate system designs by utilising the feedback from the adoption research.
4. Take the empirically-derived favourite design and develop into new functioning financial advice application, implementing all known security requirements within PSD2 regulation at the time of creation.
5. Compare new system against existing mobile banking solutions to evaluate its success and potential adoption.
6. Evaluate the success of the study, propose guidelines and offer areas of future research and development made possible by PSD2.

Limitations

As a subject there is an almost infinite number of possible avenues that could be chosen to drift down as part of this dissertation with regards to the future of mobile personal finance management. The focus on just one idea should therefore not be seen as a real limitation of the study but as an early stepping stone in the research of this field as a whole by creating a detailed study into the new and innovative area of integrating price comparison with account management.

The main limitation of the project is that the system will be created prior to the release of PSD2, meaning it will be impossible to create any software solution that will 'work' during the project's evaluation period. However, the long-term effects of this will be negated via the implementation of any API and security specifications released by legislators by the time of application development, filling in missing information and data with plausible mocks to provide an operating proof of concept to test on users.

Brexit Another thing to note is the potential for this research to be effectively voided for the foreseeable future in the UK thanks to its reliance on the EU-enforced PSD2, which a

'post-Brexit'[2] British government could choose not to implement.

This could be a tangible possibility should the large British banking institutions choose to exert pressure against the legislation, which they may have an incentive to do in fear of being displaced in the markets. As discussed by Khan (2016) and Gough (2016), PSD2 represents a threat to banks in a number of ways, though Gough in particular is a clear advocate of British banks still embracing the directive in order to keep *regulatory equivalence* with the European markets even if not legally obliged.

However, with the *Open Banking Working Group*, a collection of UK institutions collated by request of the HM Treasury, having already published their *Open Banking Standard* (OBWG 2016) - which actually goes above and beyond the open nature of PSD2 in the opinion of Ohlhausen (2016) - the UK does look likely to embrace the new regulations.

1.1.3 Resources

The list of potential resources that will be needed to achieve the project objectives.

Research

The main resource required to carry out the research will be access to a willing user base for feedback on the initial low-fidelity designs and then further testing on the developed application later on in the project. These users must be a variety of ages and technological abilities to get a clear view on the suitability of the suggested options.

For initial user data collection, the study will also look to review how interviewees rank their interest in controlling their personal finances to ensure there is a good variety. This is because desire for the system may differ vastly dependant on whether participants are regular users of price comparison services or have never 'shopped around' with regard to their finances.

Technology

The system will be based off development of a mobile application native to its own environment, as using a web application would make it harder to implement the necessary level of security or use hardware features, such as fingerprint recognition, effectively.

[2] Brexit: "Departure of the United Kingdom from the European Union" (https://en.oxforddictionaries.com/definition/brexit)

The development environment will likely be Android because of the free development and testing offered, as opposed to needing to pay for a development licence and test phone to develop an iOS application. Android boasts a larger range of users thanks to its lower cost (Farahat and Bhatia 2016), whilst research by Kim, Ha, and Park (2015) suggests Android users are more likely to care about perceived trust and usefulness than of innovative design compared to iOS users. This seems ideal for this study as it will be focused more on creating useful applications leveraging PSD2 than on developing fully completed interfaces.

1.1.4 Contents

The remainder of the dissertation is split into five primary chapters:

Literature and Technology Review First is the literature and technology review, where a compilation of related papers have their findings extracted and critiqued accordingly. This should build a picture of the surrounding industry environment that any new application would look to assimilate into, with a focus on the security and ethical implications involved in such enterprises.

User Adoption and Application Design The user adoption section follows from this, using findings from the literature review and some initial first hand user research to decide on the boundaries of what the application should aim to achieve. The research will focus on using appropriately designed questionnaires to further understand the public perception and potential adoption of the proposed system. Feedback on relative desire for different functionality areas combined with the background research will fuel the creation of a comprehensive requirements set for the system.

Design and Prototyping This section will initially contain several competing design sets in low-fidelity prototype form to gauge user approval for each, iterating over designs and evolving into interactive high-fidelity models that could best obtain useful feedback from potential users. The empirically-derived 'best' design set will be developed into a working Android application for further evaluation.

Evaluation Design and execution of a suitable experimental process will follow development, allowing a thorough evaluation of the solution's success in optimising user adoption and competing with its principal adversaries in the post-PSD2 mobile finance market.

Conclusions and Future Developments Finally, a conclusion section will summarise the overall findings of the research and propose a set of guidelines for other developers, both from the banking sectors and those new to the market, to observe when looking to take advantage of the changing market in the wake of PSD2.

Chapter 2

Literature and Technology Review

This chapter contains the literature and technology review, where a selection of peer-reviewed established and more contemporary papers will be discussed. Analysis of these is used to help give a greater perception of the problem area and shape the way this project seeks to address the issue.

The review is split into three primary sections, with subsequent partitioning within each: *Industry Background* aims to explore the environmental context of the system, *Project Considerations* looks at the technical and ethical issues related to creating the proposed application whilst *Research and Development* concentrates on the research and evaluation methods used in related papers.

2.1 Industry Background

It is important to get a thorough appreciation for the current mobile finance and price comparison environments to understand the strengths and flaws in each. This can help uncover a strategically targeted place in the market for new applications, with a clear unique selling point that takes the successful parts of existing offerings whilst being able to offer something new thanks to the consequences of PSD2.

Along with a background study of the finance market, the section will discuss the simple beginnings of mobile banking and key developments in the field since. This will follow with a snapshot look at the outbreak of the FinTech movement and the third party payment providers within it that stand to gain a lot from PSD2's implementation, before a quick study on the alternative payment methods of *Bitcoin* and *Blockchain* and how they could impact the payment industry. The section concludes with a look at the price comparison industry, with the integration of that and mobile banking being the key unique selling point that this paper aims to utilise.

2.1.1 The Mobile Finance Culture

Technology has become an "increasingly vital element" in the financial service industry, changing the "whole nature of selling and buying" products in the sector (Suoranta and Mattila 2004, p.1). Within the finance sector as a whole, it is generally recognised that "banking was at the forefront" of financial services in taking fast advantage of new developments to move customers from the traditional face-to-face to "computer-mediated" based transactions (Karjaluoto et al. 2010, p.411).

Whilst the form of technology being utilised for retail banking has changed over the years, from the game-changing automated teller machines appearing in the late 60's (Bátiz-Lazo and Reid 2008) to the push to internet banking, the latest and potentially most exciting service delivery medium is the mobile phone. This has become the focus of development in the customer delivery of banking services, for many people personifying the trend to "deconstruct banking services", challenging the "fundamental justifications for building large banks" and providing a platform to bring new players into the industry (Harrison and Estelami 2014, p.335).

Usage and Adoption

The speed of adoption of online finance services, in particular internet banking, has been immense in recent years. American internet banking usage stood at 61% of the population in 2014, a similar level to the omnipresent social networking sites, with a large proportion of these using mobile banking to log into their online accounts (Harrison and Estelami 2014, p.352).

Recent research has also shown indications that mobile banking users will actually log into and check their accounts more often than their non-mobile counterparts. A British Banking Association study for 2015 found that Barclays[1] mobile users accessed the app on average 28 times per month (BBA 2015, p.21), suggesting that mobile banking may incentivise a more active style of account management.

In other usage-focused studies, Laukkanen and Pasanen (2008) found that "younger customers are more willing to adopt mobile banking innovation than older customers" (p.93). Meanwhile, in their analysis of consumer behaviour, Suoranta and Mattila (2004) found that the level of innovativeness is strongly correlated to the age demographic, with the elderly "considered resistant to change" (p.364) with a negative attitude to technology.

These findings, when viewed together, could suggest the coming of a new generation of banking users that take greater active management of their finances via the mobile medium.

[1]Barclays: One of the largest UK high street banks (see www.home.barclays for more)

Therefore, the next few years could prove key to entice this younger generation into adopting new services as it moves towards displacing the current highest earners in the country.

Basic Beginnings

Harrison and Estelami (2014) noted that "initial success of mobile banking was limited, especially when the services used a simple SMS structure" (p.335). However, as mobile technology has developed, so have the banks offerings and different needs were able to be met after the initial basic service, providing a distinct utility to traditional online banking (Laukkanen and Pasanen 2008).

Back in 2004, a study by Pousttchi and Schurig (2004) used study groups to attempt to discover customer requirements for the new sector of mobile banking applications. This found only four use cases that the study groups could ever imagine using a mobile app for: balance requests; control of account movements; instant payments and account administration/transaction execution. With the advancement of the sector over the last 13 years, these can now be considered the very bare-bones of any mobile banking system.

However, with new technologies bringing faster and easier access to the Internet, consumers have become more technologically educated, reducing their uneasiness around mobile banking and visibly changing "consumers' behavioural patterns" in relation to interacting with their financial institutions (Luo et al. 2010, p.223).

Developments

From these basic essentials offered by mobile banking apps, there have arguably been few noticeable innovative developments. There have been attempts at changing things around; the *ATM finder* feature, where users can use their phones location services to route to the nearest physical ATMs (Oliveira et al. 2014), was perhaps the first attempt to offer something new that could not be achieved via usual online banking delivery.

Since then, there have been attempts to integrate new features to mobile apps based on new technologies introduced to the phones they run on. For instance, a number of apps now allow authenticated login via fingerprint to make use of the new slew of fingerprint-reader enabled phones (Cao and Jain 2016). More important perhaps is the recent addition of Apple and Android pay support to apps by some banks. These services have become a popular trend through 2015-16 with high youth uptake in particular, allowing users to use their phone's NFC[2] chips to perform contactless payments in day-to-day purchases (Wang,

[2]Near Field Communication (NFC): "Contactless communication between devices like smartphones or tablets" (nearfieldcommunication.org)

Hahn, and Sutrave 2016).

Whilst these features and security additions have come with the natural evolution of mobile banking, mixed with integration of new mobile phone features, the field of *smart banking* is perhaps the first major shake-up since finance apps first made it to phones. Smart banking is defined simply as banking apps based on a smartphone, with inferred features such as giving user feedback on their day-to-day spending providing 'smart' suggestions on how to save money by analysing purchase patterns (Kim, Ha, and Park 2015).

2.1.2 Disruptive Payments Industry

The Rise of FinTech

The last few years in particular have seen a concentrated driven effort by startups and smaller financial players that have seen some of the established firms whipped into a frenzy in an attempt to not get left behind. This movement has marked the first time financial innovation has been aimed at embracing technology and lowering costs for users, as opposed to the previous focus of finding loopholes in regulations that has long been the staple 'innovation' of the banks (Mackenzie 2015). This development of new and disruptive financial alternatives is now known collectively as *Financial Technology*, or simply *FinTech*.

The popularity and perceived financial viability of the FinTech industry has increased hugely this decade, with global investment in FinTech ventures tripling in 2014 to $12 billion (Bruggink 2016). Bruggink ventures on to say that the industry has manifested so rapidly because of the "growing gap between customer's technology expectation and banks ability to meet them" (p.10), suggesting that the appetite for alternative modern financial services is on the rise.

Established banks are understandably beginning to feel threatened by the FinTech movement and its potential to "sap the sector's profitability", fuelling a move to invest in the sector (Economist 2015). However, these banks are still lagging behind in this, with banks accounting for just 19% of the FinTech investment in the game-changing 2014 year (Cortet, Rijks, and Nijland 2016).

The opportunities presented by PSD2 look to be the next feeding ground for the FinTech industry to thrive off. As discussed by Cortet, Rijks, and Nijland (2016), the main question for the banks when implementing their open APIs is whether to offer "a limited portfolio" (p.21) of services as specified by PSD2 to fight off business encroachment by the FinTech industry, or to extend and themselves develop new applications to "compete directly for customer relevance" (p.21). However, startups have the advantage of speedy development and release in order to quickly take advantage of changing markets, whereas established

banks have to combat organisational hurdles and legacy infrastructure to offer new services (Guibaud 2016). This results in a situation where FinTech challengers, if they can take advantage of the market effectively, are well positioned to "take business away from traditional, incumbent banks" (Cortet, Rijks, and Nijland 2016, p.26).

Third Party Payment Providers

As mentioned in Section 1.1.1, the PSD2 regulations will require institutions to allow third party payment providers (TPPs) access to certain account data. TPPs do not directly offer accounts but instead "aggregate information" for consumer's existing bank accounts and allow interactions such as online payments via these (Valcke, Vandezande, and Velde 2015, p.6). However, with the amount of sensitive information involved and bank account credentials needed for using current services, legislators are aiming with PSD2 to enforce greater security by making the TPPs 'trusted' third party accessors of APIs as opposed to requiring full account logins to access data directly.

This stands to make the field of third party payment providers much more appetising and potentially lucrative for investors to look into, with the mantle of payment supremos potentially due to pass from the big banks to the smaller players.

FinTech Examples

Two main players in the FinTech market have already looked to embrace the futuristic open nature of banking by releasing open APIs that can be used to access key account functions, giving potential for users to create their own personalised interfaces.

Monzo Monzo is well and truly aimed at the millennial generation, looking to offer a fully fledged smart banking app to eventually integrate features like bill splitting and spending tracking - in their own words, Monzo "isn't your typical banking app"[3]. Still being in the initial roll-out stage, the app currently does little different to a 'usual' banking app other than provide instant notifications when spending money.

What makes Monzo different is how they have released their API and actively encourage consumers to build their own apps to manage their account, claiming to take on ideas and feedback to decide what they next implement in the primary app. This fresh approach to banking could prove to be the key to getting high adoption levels from younger users, with a future setup likely to include several third party interfaces for the bank on mobile stores for users to choose their favourite as opposed to having to swap banks to get a different user interaction.

[3]Monzo - https://monzo.com/home/

Fidor Where Monzo currently only offers a pre-paid card to use, Fidor is comparitively established and more recognisable as a traditional bank. However it also looks to entice younger users - having only moved to the UK in September 2015 (having operated in Germany successfully since 2009, Moewes, Puschmann, and Alt (2011)) the online-only provider gained attention for its somewhat different social-media based operations, including the interest rate level for their basic account being set in accordance to the number of 'likes' their Facebook page had at the time (Lunn 2015).

This is all part of their effort to "re-establish lost confidence"[4] in the banking industry following the latest market crash in 2008, claiming to refocus attention from financial advisers to what consumers want from their money management. In a similar attitude to Monzo they have released open APIs for accessing their services through a third party, though whilst these could be used through an app the focus seems to be on web interfaces.

Account Aggregators

Account aggregators and spending trackers have started picking up popularity in the last few years in the UK. These offer spending feedback and metrics based either on user-entered data or, increasingly, through accessing users' bank accounts directly on a read-only basis. However, whilst these could be converted to work upon the trusted third-party system proposed via PSD2 when that comes into force, the account aggregator apps currently require full login details for each bank account to import them - information that many are, understandably, unwilling to entrust.

Whilst *Mint*[5] has been making waves in the US for a number of years, it has yet to make the move across the Atlantic. In the UK, the most established aggregator is the OnTrees personal finance app[6], now owned by the MoneySuperMarket group. This however still has under 50,000 downloads on Android in three years of availability, with low user reviews averaging just 2.2* suggesting a number of issues with the product[7].

Virtual Currencies

The area of transactional finance garnering the most mainstream attention in recent years is the *'virtual'* or *'crypto'* currency space, mostly thanks to the exciting and unpredicted emergence of Bitcoin. These could yet prove the future transaction medium of choice if their popularity continues to rise.

[4] Fidor - https://www.fidorbank.uk/about-fidor/about-us
[5] Mint on Android store - play.google.com/store/apps/details?id=com.mint
[6] OnTrees on Android store - play.google.com/store/apps/details?id=com.ontrees.android
[7] As of April 2017

Bitcoin Though by no means the first virtual currency, with similar ideas proposed as far back at the 1980's (Barber et al. 2012), Bitcoin has become the first widely used and most famous virtual currency of all time since its release as a concept in 2008 by mysterious creator Nakamoto (2008). The concept of the cryptocurrency is to allow direct transactions between persons without the need of a trusted third party such as a bank by relying on protection via cryptographic transactions being "computationally impractical" to reverse (Nakamoto 2008, p.1).

The decentralised currency network relies on a public log, the *blockchain*, which records Bitcoin transactions between clients (Eyal and Sirer 2014). Users can gain the virtual currency via *mining*, where their computational resources are used to "solve computational puzzles to generate new bitcoins" at a predicatable gain rate (Barber et al. 2012, p.2), thus providing continuous validation computation to the blockchain (Böhme et al. 2015).

Usage and value of the Bitcoin has spiralled since 2013, during which one Bitcoin went from being worth \$14 on the 1st of January to trading at over \$1000 by November[8]. However, a natural decrease of coin minting levels (eventually down to zero) within the currency algorithm means that transaction costs may increase in future, as with no further bitcoin mining revenues the only way to make money will be via verifying transactions (Böhme et al. 2015). There is also the issue that the lack of regulations or authority accountability makes Bitcoins an attractive target for thieves; several large Bitcoin 'secure' wallet providers have lost hundreds of thousands of dollars worth of customer coins from malicious behaviour (Barber et al. (2012), Valcke, Vandezande, and Velde (2015)).

With PSD2 set to allow lower transaction rates, one of the main perks of Bitcoin use, it seems unlikely that Bitcoin will ever grow much larger than its current state, meaning it can be discounted as a major rival to any TPP system. However, Bitcoin will always likely have followers for the factor of anonymity that has made it popular with certain consumers, as it has none of the regulation that stops sales of prohibited items that forms one of the fundamentals of all other major payment methods (Böhme et al. 2015).

Blockchain Where Bitcoin will never achieve mass consumer adoption, for its lack of security and regulation if nothing else, *blockchain* has become a buzzword for many large and trusted financial players in the past year and could prove a future threat for TPPs who stick to traditional methods.

The attraction is clear for big players to get involved, with near real time, basic and trustworthy transactions potentially executable across the planet if blockchain technology was properly implemented to handle the contractual complexities of financial products (Caytas 2016). This could also push costs down - a lucrative proposal, with a study by Wyman (2015) putting the worldwide cost of clearing and settlements to be up to \$80 billion for

[8]Source: www.xe.com

the banking industry in 2015 (p.8).

A number of the big banking institutions have started research into how they could implement blockchain technology. Goldman Sachs is one of the most vocal advocates, to the extent of releasing an 88 page report to clients stating the possible use cases and advantages of a blockchain-based future. In this they predict industry savings of $11-$12 billion just by moving to shorter settlement windows for cash securities trading by applying blockchain to the clearing and settlement process (Goldman-Sachs 2016, p.5). It also lists a number of other potential advantages, with particular focus on the benefits of moving foreign exchange transactions into a blockchain system.

However, whilst PSD2 promises to reduce transaction costs across EU borders, it does nothing to address the costs of the movement of huge amounts of money worldwide in the way that blockchain technology could. With the technology "still in its infancy" (Caytas 2016, p.7) it appears the large corporate backers are mostly just testing the waters with blockchain, as opposed to looking to adopt it for mainstream use any time soon - in their report Goldman-Sachs (2016) predicted around 10 years for broader acceptance of blockchain to occur (p.5), and they stand as one of the more optimistic on the subject. From this it can be concluded that whilst new corporate-backed blockchain is sure to be a topic for the future, it is similar to Bitcoin in that it stands no real threat to the standard TPP - for the time being, at least.

2.1.3 Price Comparison Industry

The price comparison industry is one which has emerged triumphant alongside the growth of e-transactions, with consumer mindsets now trained to find the best deals (Xu, Liu, and Shen 2013). In the past couple of years the focus for comparison sites has shifted, moving from the saturated 'standard' areas of energy suppliers and insurance onto comparing the best financial services like bank accounts and loans that customers can apply for, given some details of their monetary situation.

Major Sites

In the United Kingdom there is a vast number of comparison sites addressing a huge variety of products and services, but for the large multi-purpose comparisons a select four have emerged as leaders: MoneySupermarket.com, CompareTheMarket.com, Confused.com and GoCompare.com (Harrison and Estelami 2014, p.336).

To take one as an example, MoneySupermarket now offers comparisons on loans, credit cards, savings accounts, mortgages, ISAs and debt management along with a number of others. If looking to compare savings accounts, a user can insert their desired features

(high-interest, easy access, etc) and have accounts ranked accordingly. However, the user then has to read through the small print on each to determine whether accounts are suitable for them based on their requirements. Other comparisons like car insurance are far more established, with 67% of buyers using at least one comparison site when renewing as far back as 2011 (Gutmann, Lipman, and Lucas-Williams 2013, p.3). These require large amounts of personal data to be input before giving user feedback but consequently give specialised recommendations, suggesting that comparisons for financial services could improve if given more information to work with.

Current Mobile Options

Surprisingly, the main comparison sites have been slow to adopt their own mobile applications, though this could perhaps be due to having set up mobile friendly websites and relying on browser-based cookie data for tracking purposes in some cases. *Confused.com* now has an app but this only addresses car insurance and not any of their other products[9].

MoneySupermarket meanwhile have recently released a more fully fledged option on Android to launch onto the mobile application scene. *MoneySupermarket GO* includes a number of interesting features that could end up achieving more revenue for the company, such as making notes of insurance renewal dates in order to remind users to search for quotes via the app at the appropriate date (see Figure 2.1). It also makes an attempt at gamification via awarding badges for performing certain actions on the app, though whether this has any positive effect on user adoption remains to be seen.

However, the *GO* app just links users to the mobile website for most comparison operations and appears to contain some serious bugs based on user reviews on the Android store, with a number of complaining 1* reviews[10]. From this brief overview, it can be suggested that there are no suitably usable mobile apps for price comparison at this time.

2.1.4 Summary

This section aimed to discuss the evolution and current state of mobile finance in an attempt to indicate room in the business space for new and innovative applications. From this it can be concluded that the traditional high street bank is the provider of the primary mobile finance apps, having been somewhat innovative originally in pushing out mobile banking to a limited market, but perhaps having slowed down considerably in their offering of new technology, especially in terms of exploiting the features of modern smartphones.

With their hesitation has come the insatiable pull of the *FinTech* movement, capturing

[9] Confused.com Quickquote - https://play.google.com/store/apps/details?id=com.confused.quickquote.test
[10] Accessed 18/11/16 - https://play.google.com/store/apps/details?id=com.moneysupermarket.moremoney

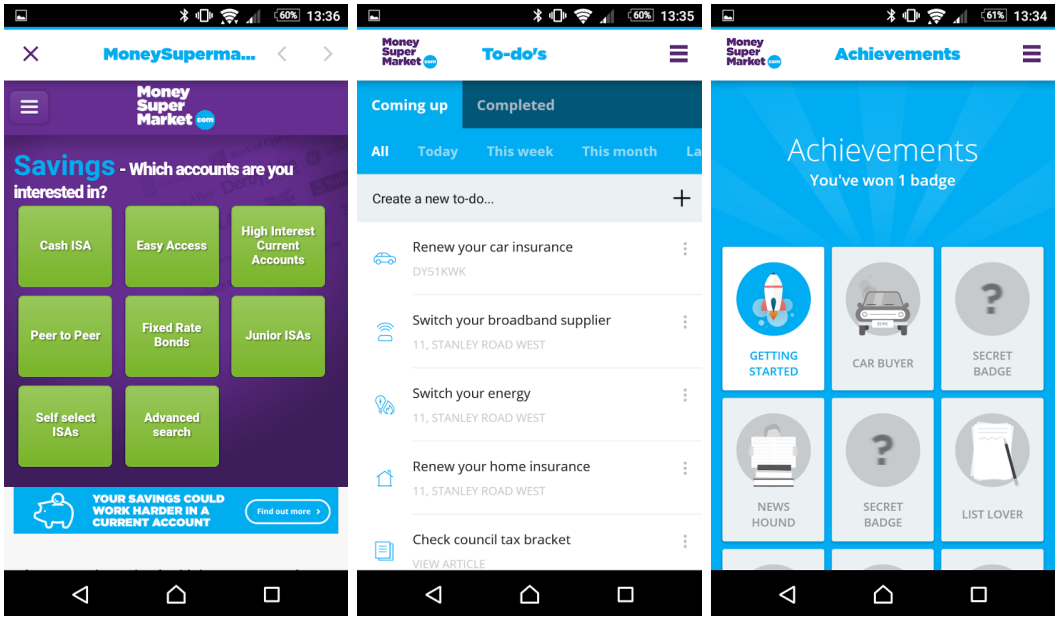

Figure 2.1: MoneySupermarket GO Android application: Available services, renewals reminder list and gamification badges

market interest away from and becoming a legitimate threat to the traditional banking institutions. These modern firms are perhaps then standing at the forefront of those looking to take forward the payments market, whether as a new TPP to take advantage of PSD2 or as a flexible small new bank like Fidor or Monzo.

There is now also the potential threat of the *crypto-currency* to consider, with some Blockchain-based solutions now backed by behemoths of the banking and finance world since the breakout success of Bitcoin in the past three years. Whilst the big-company backing does lend a sense of trust and authority that was lacking in the regulatory-less Bitcoin world, it does not look like being a serious threat to traditional payment services for at least the next ten years (Goldman-Sachs 2016, p.5).

However, whilst the older banks have been accused of being slow to evolve their mobile offerings, it may be for a reason *other* than their often monolithic approach to new technology. Harrison and Estelami (2014) have suggested that it is not always in the best interests for banks to offer new and exciting products, remarking that "novelty is often hard to deliver for an extended period" (p.340). This approach could be best appreciated by looking at the demographics: younger customers are the ones most likely to move for innovative products (Laukkanen and Pasanen 2008), but these are not the prime targets for banks as older users will generally have a higher wealth, whilst users swapping banks for the sake of a novel application are unlikely to be ones who stay loyal once that novelty

has worn off. Instead banks have mostly focused on delivering a suite of complementary products and services, meaning once this suite is adopted by a user they become effectively "locked-in" to the bank's services (Harrison and Estelami 2014, p.340).

The huge variety of comparison content provided by the main four price comparison sites, including a number of financial product comparisons, means that any one could prove an ideal partner for a new application integrating price comparisons with account management. This could prove a very productive match-up for consumers, as price comparison websites currently offer a reasonably bare-bones advice section for products such as bank accounts, meaning feeding in real data could be key to give useful and easy suggestions for saving money. There is also little existing competition in terms of mobile apps, with only two of the four main sites offering any kind of app and each having its own big disadvantages that have stopped widespread adoption thus far.

The next section looks into the areas of *mobile security*, *data mining* and *ethics*, as carefully planned approaches will be required to deal with the issues related to each in this project.

2.2 Project Considerations

Having taken a look at the environment into which the proposed application will be integrating, the following section concentrates on the operational and ethical considerations involved in the creation and monetisation of the system.

2.2.1 Security

Due to the nature of the financial apps, they will always have to be concerned with how to protect the personal data entrusted to them - according to He et al. (2015), the understanding of "emerging threats, vulnerabilities and counter-measures" of banking applications is "critical to the future of mobile banking" (p.1).

As discussed in the PSD2 background (Section 1.1.1), all third party providers like this will require some certain, currently unspecified, level of security certification in order to pass authentication and be trusted by banks to use their APIs. This next section looks at how the public perceives the level of safety offered by mobile banking, along with common threats to mobile devices from applications.

Perceptions of Mobile Banking Safety

There is the suggestion by many papers that user adoption of banking apps is limited by negative perceptions of security (Ferris, Stahle, and Baggili (2014), Kim, Ha, and Park

(2015), Luo et al. (2010)), meaning a transparent and effective attitude to security may be key to persuading more consumers to make use of mobile finance applications. Ferris, Stahle, and Baggili (2014) suggest that it is a lack of knowledge from users that causes issues, as they are "wary of putting their financial resources in danger" when they are not sure what security concerns actually exist. This is backed up by research undertaken by the U.S Federal Reserve, as seen in Figure 2.2, that clearly shows that non-users are either unknowledgeable about or distrustful of mobile banking provision.

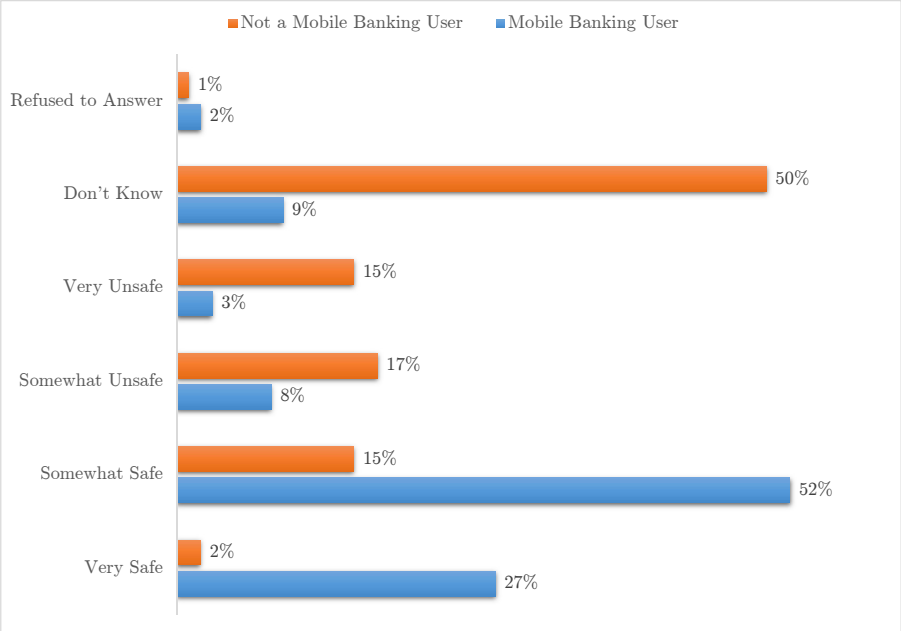

Figure 2.2: U.S. Federal Reserve study on how 2280 interviewees felt about security of mobile banking for protecting personal information (Reserve 2013)

The public perception of mobile banking has also not been helped by high-profile breaches of online banking security in the UK. For example, in 2010 Barclays were accused of neglecting security in favour of usability when over-simplification of their online banking login page allowed illegal access by third parties (Smyth 2010), leading to increased security steps in the login process. However, Potter (2006) concludes that security cannot come at a decrease to usability and Gummerus and Pihlström (2011) suggests that ease of use is the most attractive thing about mobile banking. Viewing these alongside the risk of breaches points towards needing to achieve a balance of security and usability to earn and maintain a good public perception towards a given product.

Threats to Mobiles

There exist a number of different methods of attacking mobile devices that both bank applications and users have to be wary of and do all they can to avoid leaking sensitive information. A distinctive lack of academic research into the threats against banking apps led He et al. (2015) to adopt the novel approach of using blog mining to augment the relatively small quantity of published peer-reviewed literature. This research led to the discovery of the five primary threats for mobile banking: mobile malware, third party applications, fraudulent applications, unencrypted Wifi networks and app vulnerabilities.

Mobile Malware Malware is the category encompassing viruses, root kits and trojans. Much of the mobile malware out there are variants of existing malware that affect traditional computers and mobile banking (Webroot 2014). Cyber-criminals have refined these malware to specifically target bank accounts once on a mobile device, with efforts made to thwart new security defences built into mobile banking (He et al. 2015).

Third Party Applications TP applications, here defined as ones not downloaded from the official Android Market/iOS App store, can secretly tamper with existing banking apps on the device and be used to extract account data (He et al. 2015).

Fraudulent Apps Fake applications can persuade consumers that they are a different, legitimate application but can contain malicious code to steal users bank account login details.

Unencrypted Wifi Networks Public wireless networks are not always secure, with eavesdropping possible on these public forums by criminals that can be used to monitor other people's use of mobile banking over Wifi to extract sensitive information (Legnitto 2013).

App Vulnerabilities Exploitable app vulnerabilities can be a serious issue when discovered by hackers. For example, many banking apps lacked protection against reverse engineering of code as of 2014 (Buckley and Varney 2014).

Ways to Counter Threats

The Android mobile operating system aims to help users understand the security concerns of apps by enforcing acceptance of permissions when installing new applications. Felt, Greenwood, and Wagner (2011)'s study on Android permissions concluded that the permission requirements are generally beneficial to system security, though in their study of nearly 1,000 applications they found that 93% of free applications required at least one

permission on installation that could be considered dangerous (p.80).

Kelley et al. (2012) concluded simply that "users do not understand Android permissions" (p.78), leading most to simply ignore them. This is understandable given their findings that users are largely uninformed about the existence of any malicious activity at all that could come from the Android market and suggests that permissions alone cannot make the average user fully aware and so responsible for any questionable actions by their apps.

To help prevent malicious attacks on legitimate, non-fraudulent applications there have been a number of suggested approaches. Modern approaches to security in the apps include using two-factor authentication and suitably complex levels of encryption. Recently some banks have also started using the fingerprint readers present on some modern handsets, suggested as a potential authentication method along with voice recognition software by Fatima (2011). Personal biometrics do have their own vulnerabilities though, so it is best to combine these with other authentication methods for stronger verification (He et al. 2015).

2.2.2 Data Mining

The proposed application will need to rely on some form of data mining in order to extract the user's finances to export to a price comparison provider. Data mining can be defined as a process using artificial intelligence and machine-learning techniques alongside statistical analysis to extract useful information (Turban, Sharda, and Delen 2011, Tavani 1999). Bigus (1996) describes it as a method for "efficient discovery of valuable, nonobvious information", which is "increasingly being seen as an essential business process", either via first-hand data collection to employ in customer relationship management programs or to sell to other businesses (Danna and Gandy Jr 2002).

In the case of financial applications, there are many potential implementations of data mining that could lead on to useful consumer feedback. Techniques like neural networks and decision trees could "be used to seek the profitable segments of customers" by analysing their "underlying characteristics" (Ngai, Xiu, and Chau 2009, p.2954). It can be suggested that by having such a large amount of indisputable and personal financial data about users, any application using data mining on top of bank account access could have the potential to derive wide ranging characteristic information, especially in terms of economic demographics.

2.2.3 Ethics

One of the main focus points when conceptualising the system, due to the basic nature of its operation, must be the ethical implications involved. With the essential premise of the project being to explore the ways to integrate users' personal financial data with

third party price comparison sites, a strict ethical code must be created to avoid consumer exploitation.

Data Mining Ethics

The act of data mining in itself has "serious ethical implications" (Witten and Frank 2005). Fule and Roddick (2004) have the opinion that with data mining, "the ability to harm or cause offence can often be inadvertent" (p.159) and offer a number of approaches to try to avoid these cases. Danna and Gandy Jr (2002) add that there will always be social costs when business decisions are made based on data mining.

The most important ethical issue around data mining is that users must be aware of the data collection and understand how it is being used in order to withhold consent if they are not happy (Van Wel and Royakkers 2004). However, they do concede that it is probably impossible to ever develop comprehensive guidelines covering every possible ethical misuse of data mining; all an innovator can attempt to do is propose a basic moral code for new applications in the area and hope that developers take on the spirit of these in all they do, as opposed to finding loopholes in any rules.

Ethics in Monetising

Ultimately, the real goal in developing systems like this is to generate revenue from them. However, there are of course a number of ethical considerations when looking into how to monetise people's financial information.

Take the example from Witten and Frank (2005): if supermarkets mine shopping habit data and find that people often buy beer and pizza together, do you move these closer together to help the customer, or further apart to maximise time and thus potential money spent in the store? The same can be applied to the data that will be harvested through the proposed application - it could genuinely try and ensure offers shown are always in the customer's best interest, but future developers taking on the concept could certainly tailor things to their own ends.

There has already been a history of price comparison sites misguiding consumers for their own purposes. Whilst the mainstay of comparison sites is referral fees, which can be around £45 for a single credit card customer or even up to £100 for a loan, some sites have been found to prioritise deals with providers that pay the comparison site more - even when these are not the best product for the customer (Evans 2008, Harrison and Estelami 2014). There have also been problems with certain providers not showing up fairly in comparisons if they failed to establish a commercial deal with the given website.

This led to the introduction of new guidelines by the Financial Services Authority (FSA 2011) to try and improve the fairness and transparency of the comparisons made. There have been visible improvements in the market; for example, *MoneySuperMarket* now offer a 'How our site is paid for' tab explaining that they make money through referrals and that some providers will not show up if they have opted out of being included in search results. However, there are still certain doubts about the big providers' impartiality. With any commercial partner of the app having the ability to ruin the app's reputation should its own be tarnished, work must be done to try and ensure full trust in the system.

Real-World Moral Codes

To inspire some moral compass for use with this project, real-world examples could be taken on and suitably altered to fit the required use cases.

However, the problem with developing in this area is that personal finances are usually a tightly closed off and protected affair, with banks jealously guarding their customers against the threat of poaching. This means that there exists little in the way of real world moral codes for us to follow when creating the app, as the idea of sharing such data outside of a single institution is such a new concept. According to Danna and Gandy Jr (2002), the only reliable test of the ethical state of any business is "the extent to which it can be exposed to the light of public review" (p.384), suggesting using the 'Golden Rule' test, as suggested by Spinello (1996), decreeing that one should not do anything to another that they would not have done back to them.

There have been suggestions that financial innovation is often questioned by both the public and experts alike for the destructive consequences that follows, even for 'good' like the credit card when taking accounts of the socially destructive effects it has caused (Boatright 2013).

2.2.4 Summary

This section aimed to address the essential background considerations required for conceptualising and developing any new application based on mining data from bank accounts to work with price comparison sites.

Few papers were found that gave supporting background knowledge for anything but a tiny portion of the considerations needed for this particular space in the market. This highlights the innovative nature of this project and so potential benefits to the academic community once this topic becomes more popular in the coming years. Despite the limitations, a look at the general risks facing mobile devices and mobile banking applications in particular is certainly useful for producing a comprehensive solution to the required security level, once it is announced by PSD2 legislators.

The main focus of this section, due to the lack of details of implementation thus far available, was to examine ethical implications from each aspect of the project. Research into the data mining sector gives useful past experience in the need for proper mining guidelines, so as not to go beyond the limits of what customers have expressly given permission for upon their personal data. A concentrated look at the past controversies in regard to the price comparison industry gives an indication that ethical guidelines for the extent to which users can be monetised must be paramount in the planning and execution of both this project and any following on in future.

However, the nature of the market means any new financial technology will intrinsically be abusable and thus have question marks over its ethical status - as Boatright (2013) concluded, the "dangers of innovation are inevitable and may be inseparable from the benefits" (p.11). This means that even with a solid ethical backbone for the project, public perception of its credibility may still be a key issue when encouraging market adoption.

The next section will look at the research and analysis methodologies adopted in similarly scoped papers in order to approach an informed choice of technique for this project at each evaluation stage.

2.3 Research and Development

This section of the literature and technology review will investigate the research performed by academics in related fields. Analysing the ways they have performed and evaluated their research should indicate the best ways for this study to carry out user studies.

It particularly focuses on user adoption research, as the potential take-up of such a system is the key measure of how successful the post-PSD2 sector can become and forms an important part of the creation of further development guidelines at the end of the process.

2.3.1 User Adoption Research

For academics, the issue of user adoption has been a focal point within mobile commerce since it first emerged as a subject in the mid-2000's (Xianpei Hu and Hu 2008). As Wang et al. (2003) concluded in the earlier days of development, "considering the millions of dollars that have been invested in Internet banking systems worldwide, it is of paramount importance to ensure that people will actually use them" (p.514).

There are various methods available to predict adoption, some of which are detailed below. These are designed to offer predictions on the potential user uptake of various information

systems such as mobile banking applications to assist in the design process, as considerations of contributing factors are needed in the early stages to optimise potential adoption figures.

Technology Acceptance Model

Based mainly on the Theory of Reasoned Action (TRA, or Fishbein Model), which claimed behaviour is directly controlled by behavioural intention (Ajzen and Fishbein 1975), the *Technology Acceptance Model* (TAM) was first proposed by Davis Jr (1986) in his PhD thesis. Appreciating the impact of behavioural intention, the TAM aimed to focus on how this intention is influenced by underlying factors of perceived usefulness and ease of use of the product - that is, the extent to which people believe the product would improve their work performance, and their perception of how easily they could operate said product (Wang et al. 2003).

The primary aim of this is to attempt to predict whether users will accept and voluntarily use systems, but flaws include omissions of trust considerations, especially important in the mobile commerce investigative field, and the model's assumption that no further barriers exist to a systems use if an individual intends to use it (Luarn and Lin 2005). There have also been criticisms of TAM's "deterministic approach", deciding whether or not to adopt a novel technology purely on a prediction of how well it will be adopted (Karjaluoto et al. 2010, p.412).

Extensions to TAM Some literature experimented with adding their own fields and considerations to the base TAM model in an attempt to make findings more applicable to the specific nature of mobile banking adoption.

Luarn and Lin (2005) extended the model to include three new considerations: "perceived credibility", "perceived self-efficacy" and "perceived financial cost" (p.873). Perceived credibility had been used previously by Wang et al. (2003) for internet banking, who defined it as the level of trust by a consumer that the use of internet banking will have no associated security or privacy risks. This was found by Wang et al. (2003) to be a useful addition to the model for internet banking, though they suggested that more considerations of user computer ability and user demographics needed to integrated into a future extended TAM.

Perceived self-efficacy and financial cost were however new constructs introduced by Luarn and Lin (2005), and their use of these in the extended TAM version was found to have improved the accuracy of adoption predictions for the field, even leading to the conclusion that more additional measures could be found and added to try and improve the model further. There is the suggestion that Wang et al. (2003)'s perceived credibility was the most effective addition, with trust considerations found to be the most important aspect of

mobile banking adoption in several studies when ignoring demographics (Wang et al. 2003, Röcker and Kaulen 2014).

IDT

Innovation Diffusion Theory (IDT) recognises that the adoption of innovation is not such a straightforward process (Karjaluoto et al. 2010). It proposes four main elements that influence spread of a new innovation: the innovation itself, communication channel, time and social system it integrates into, whilst also catagorising adopter types into brackets including innovators, majority and laggards (Rogers 2010). This can work to predict potential whole timelines of new products, recognising that the spread of innovative products relies on human capital from the early innovators onwards.

Though first proposed in 1962 (Rogers 2010), this has been observed most keenly in recent years thanks in large part to the internet as a medium for the *communication channel* of the model, leading to a number of virally spreading mobile applications.

Some researchers, such as Karjaluoto et al. (2010), suggest that TAM and IDT complement each other and sought to integrate the two. This approach can be successful in using the TAM primarily to get a predicted adoption figure, whilst using elements of IDT to gain an appreciation for the other elements and social aspects affecting the spread of an innovative product.

UTAUT

The *Unified Theory of Acceptance and Usage of Technology* (UTAUT) model (Venkatesh et al. 2003) is perhaps the best known improvement of the TAM, with the *unified theory* being based on 8 different adoption research models and has been found empirically to outperform each one individually (Oliveira et al. 2014).

Using the model helps to explain both consumers intentions to use a new product and their subsequent behaviour, splitting intentions into three primary antecedents: performance expectancy, effort expectancy and social influence - each with added influence of age and gender demographic input (Oliveira et al. 2014). In a study of mobile banking using UTAUT, Luo et al. (2010) came to the concluson that performance expectancy, that is the extent to which a potential user feels that adoption of mobile banking would help their performance in terms of account management, was the main consideration factor for adopting banking apps. This differs from the earlier mentioned studies (Wang et al. 2003, Röcker and Kaulen 2014) that found trust to be most contributing factor, but could be due to mobile banking requiring consumers to already have (and thus trust to an extent) online banking, meaning the move to mobile would likely not require such a jump in confidence.

2.3.2 Summary

There is a relative lack of literature on the subject, with a meta-analysis of published journal articles by Shaikh and Karjaluoto (2015) finding that of the 33 different journals that did publish mobile banking adoption articles, 27 of them only published a single one between 2005 and 2014 (p.133). This means that whilst the existing literature can be analysed to provide feedback about the effectiveness of using different research methods for measuring mobile adoption, there is arguably not enough to give any definite conclusions or guidelines on best practice for similar studies.

However, it would be worth taking on board these previous experiences using each model along with the individual requirements of a given project when studying user adoption of mobile commerce innovations.

Next, a study of existing applications and user adoption research will combine to create a suitable requirements set for the proposed application.

Chapter 3

User Adoption and Application Design

Following on from the literature and technology review, the next stage is to use those findings to inform the full conceptualising of the proposed system. Some first hand research will be carried out on the basis of a suitable user adoption model to get an impression of potential usage for the proposed system. The findings of this, plus analysis of the literature review and existing mobile banking solutions, will be used to create a set of system requirements to work on from in the application design.

3.1 Current mobile application offerings

Since any new multi-banking app will have to compete against existing solutions, it can be reasonably suggested that they will have to be *at least as* usable as those existing apps whilst offering the multi-banking functionality to tempt many users into adopting.

With this in mind, a study of users' opinions on current banking apps can help to identify which are the best to use as inspiration for the conceptualisation and design of the new system. Due to the lack of recent published literature and need to get the most recent opinions on functionality, this will be achieved via the mining of blogs rating and comparing UK banking apps in equal weighting with the iOS and Android app store reviews for these. This should help provide a clearer idea of what the existing solutions do well, as aiming to match their functionality and design should act as a minimum requirements set if the proposed system is to tempt users across to it.

3.1.1 National Rankings

Since a number of different institutions and technology opinion websites run yearly rankings on the best and worst mobile banking apps each year, these can be used as a good backdrop to identify the favourites and source which particular facets make these the best for consumers. Though the world of internet blog posts is obviously an unreliable source in general, the act of blog-mining over a suitable number of sources was well-utilised by He et al. (2015) to gain market data in an area unsupported by academic papers.

Though some studies only covered a subset of the main highstreet banks, the 8 most used and most commonly studied banks were chosen for further study as they had sufficient coverage. These were *Lloyds, Halifax, Barclays, Santander, Royal Bank of Scotland (RBS), HSBC, Natwest* and *Nationwide*. Table 3.1 shows results from the 7 opinion blogs reviewed, with each banks' average ranking within these results when they appeared in them.

Table 3.1: The ranking achieved relative to one another by banking apps: A- Finnegan (2016) B- Grothaus (2016) C- Smith (2016) D- BankingTech (2016) E- MoneySuperMarket (2016) F- BankingRefunds (2016) G- Copeland (2016)

	A	B	C	D	E	F	G	Average
Barclays	2	1	1	1	1	-	6	2
Lloyds	1	7	-	3	-	1	2	2.8
Halifax	-	6	-	4	-	3	1	3.5
Natwest	3	2	-	2	-	-	8	3.75
HSBC	5	3	-		-	-	4	4
Santander	4	4	-	6	-	-	5	4.75
RBS	-	6	-	7	-	1	7	5.25
Nationwide	6	5	-	8	-	-	3	5.5

As can be seen from the table, the *Barclays* app was the most chosen 'winner' of the comparisons in these seven recent articles and blog posts, closely followed by Lloyd's offering. These were judged upon a mix of feature rankings, personal opinion reviews on their usability and some mass user reviews.

3.1.2 Mobile App Store Reviews

To gain an insight into which applications have been most widely praised or otherwise complained about by real-life users, a number of user reviews were collected to view the split between *1-5** for each of the eight applications on both the iOS/iPhone app store and the Android market. These are shown in tables 3.2 and 3.3 with number of reviews and

ranked via their average rating out of 5.

Table 3.2: Ratings from the iOS app store (Collected Nov. 2016)

	1*	2*	3*	4*	5*	Average
Lloyds	2294	628	825	2957	17537	4.35
Halifax	1966	507	633	2360	13244	4.30
Barclays	2361	530	774	2222	15193	4.29
Nationwide	579	200	257	287	1222	3.54
Natwest	8649	2066	2471	3032	11993	3.27
Santander	1016	362	454	556	1198	3.16
RBS	2342	490	643	634	2335	3.02
HSBC	1804	347	248	361	824	2.46

Table 3.3: Ratings from Android Market (Collected Nov. 2016)

	1*	2*	3*	4*	5*	Average
Barclays	7823	1712	3404	18416	82355	4.46
Lloyds	4527	1508	2647	12988	52817	4.45
Natwest	3376	1206	2243	9710	38938	4.44
Halifax	4190	1313	2255	10098	37089	4.36
RBS	978	358	552	1847	6284	4.21
Santander	1828	851	1693	4676	10242	4.07
Nationwide	2309	1007	1185	2383	5954	3.68
HSBC	12983	4100	6014	10182	25684	3.53

As seen in the tables, the iOS and Android stores gave very similar review data for the banks - perhaps unsurprisingly, given that apps are usually essentially the same but ported to each device. The highest rated applications of the previous section, Barclays and Lloyds, do well again here by placing 1st and 2nd in the Android market and 3rd and 1st in the iOS store respectively.

With this mandate, the Barclays and Lloyds apps can be taken as examples of the most popular mobile banking providers in the UK at this time. Next, an investigation into their provided functionality and appearance can provide a suitable base example for the new application that should help achieve the aim of being *at least as* usable as these existing apps.

3.1.3 Features Provided

The first stage is extracting the features that the *Lloyds* and *Barclays* applications provide, as these should stand as a base set of requirements for any new system that hopes to take business from them. These were found by cross-referencing claims that each made about their functionality with the report on banking apps by market research company *Forresters* (L'Hostis and Causey 2016). The results can be seen in the Venn diagram in Figure 3.1, with those in the central shared area the primary objectives for any new system.

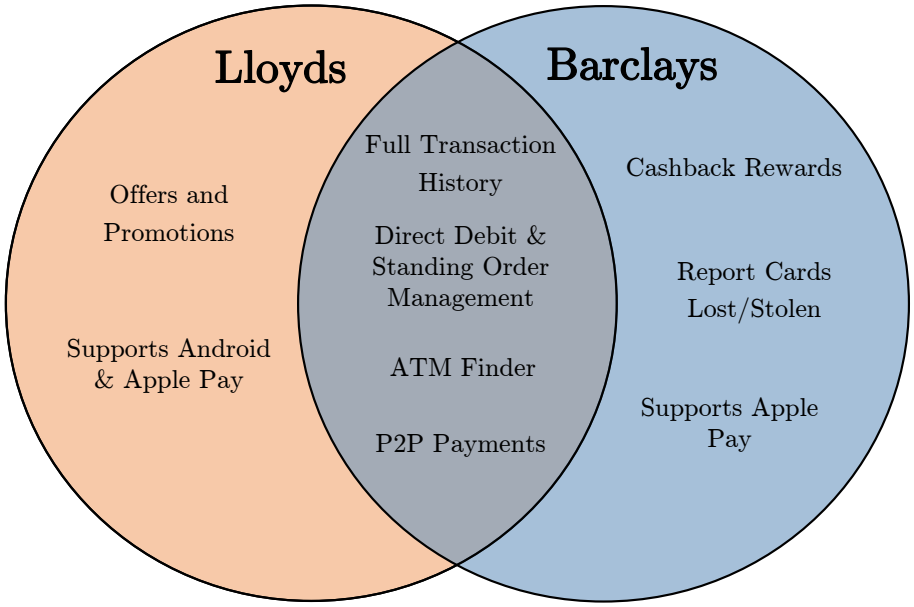

Figure 3.1: Venn diagram of Lloyds and Barclays features with key overlaps

The central pieces of functionality can be seen to be giving access to full transaction history, allowing direct debit/standing order management and providing access to an ATM machine finder and person-to-person (P2P) payments. These should therefore act as the primary goals for any new system created for mobile banking, with the app-specific additions, especially provisioning use of Android/Apple payment services through a smartphone, acting as an added bonus that may indicate why these apps are so highly rated.

3.1.4 Design and UX

The aesthetic qualities and layouts of the *Lloyds* and *Barclays* applications can also be studied to give cues for the initial design stage of the app creation. Figures 3.2 and 3.3 show visuals from each app, giving an indication of the type of information that should be visible on the accounts and P2P pages of banking applications.

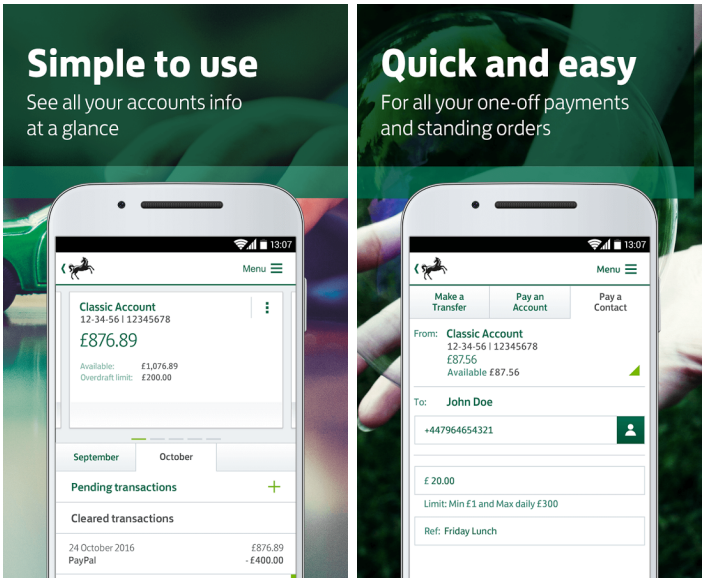

Figure 3.2: Lloyds: Picture source Android Market

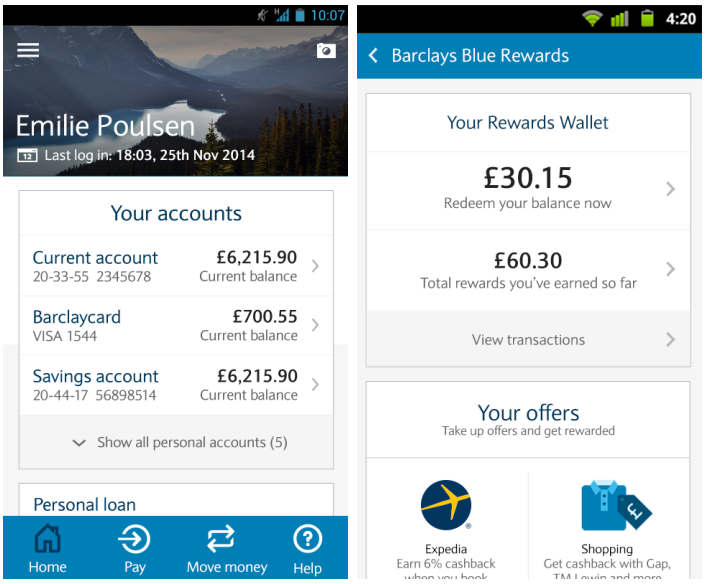

Figure 3.3: Barclays: Picture source Android Market

3.1.5 Summary

By studying the two most popular mobile banking applications from the UK's high street, a compilation of inspirations and aspirations for the suggested new system can be achieved. The features in both - *full transaction history*, *direct debit management*, *ATM finder* and *P2P payments* - should stand at the forefront of what the new application should achieve

at its base in order to persuade users to move their custom across to it. Both Lloyds and Barclays have their own basic form of offers sent to phones, mostly in the form of cashback deals, the method of delivery for which may be a good design for the price comparison feedback required in the proposed application.

Features such as Barclay's *report cards lost/stolen* do provide potential limitations: these institution-specific operations are unlikely to feature in the exemplar API for PSD2, meaning that they would be hard to implement in any third-party application. Introduction of more specific features by banks may be an important approach for them to keep custom for their primary applications in the coming years, and although this would limit the adoption of the application proposed in this dissertation it may fuel an exciting innovation period across the sector.

One type of feature that stands out in its absence is that of active spending graphs and charts for giving more visual representations to users, as offered by some of the lower-ranked services. This indicates that though those types of features may attract some users, they are not currently crucial to be highly rated in the market.

3.2 User Adoption

Following on from the findings of the literature and technology review, some new research is required specifically on the concept of potential adoption of the proposed new application. Due to the innovative new approach of multi-banking applications, especially with price comparison integration, no previous research could be utilised to give any particularly reliable indications of adoption for this project. The findings of this adoption research should feed the overall scope of the system by feeding back public perception of potential functionality that could be worked into the application to trim these down to a viable feature set for development.

3.2.1 Approaches to Modelling Adoption

In the literature review (Section 2.3.1) the most used adoption prediction models in related papers, the *Technology Acceptance Model (TAM)* and *Unified Theory of Acceptance and Usage of Technology (UTAUT)*, along with models integrating ideas from *Innovation Diffusion Theory (IDT)*, were looked at for their advantages and disadvantages. For this research the choosing of a suitable model is essential to gain a reliable indication of adoption rates and useful feedback for the scoping and design of the application.

Relative Advantages of Existing Models

The most used model in recent scientific literature has been the TAM, despite suggestions that it is too simplistic to be particularly useful (Karjaluoto et al. 2010). In an attempt to get around this, a number of studies successfully introduced their own considerations to the model. The most effectively used of these appeared to be the addition of *perceived credibility* - that is, trust of the system. Inclusion of this construct can be seen in Figure 3.4 alongside the original TAM model and its associated directions of influence. Perceived credibility consequently seems to be a crucial extension to the 'vanilla' TAM model if it was to be used for this investigation, given the impact of trust considerations and security concerns for internet banking and mobile applications.

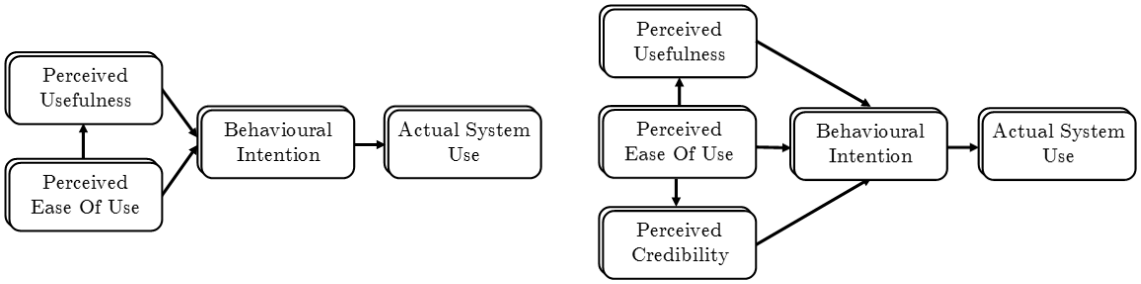

Figure 3.4: The original TAM model (left, Davis Jr 1986) and extended TAM with perceived credibility added (right, Wang et al. 2003)

There is also the suggestion by Karjaluoto et al. (2010) that the alternative IDT model (Rogers 2010) can be a useful co-component of the TAM model, as it adds in appreciation for the potential spread of innovative products that may be missed by TAM. However, integrating the IDT model in full would require including Rogers' five contributing attributes of "relative advantage, compatibility, complexity, trialability, and observability" (Straub 2009, p.630), thus it can be argued that trying to get appropriate data for and run both models simultaneously in full may be detrimental to the process as a whole due to the increased complexity. Straub (2009) also added that the IDT model was primarily descriptive rather than prescriptive in that it failed to facilitate further adoption, meaning that it was best integrated into other models.

The risk is that going too complex in a model risks descending into chaos; for example, the more recent UTAUT model's attempts to improve prediction by incorporating multiple models into one has created a behemoth with around 50 different independent variables required to predict intentions and behaviour (Bagozzi 2007). These "largely unintegrated" considerations fail to improve over the TAM, despite it missing a number of important variables (Bagozzi 2007, p.252). Van Raaij and Schepers (2008) also back up the argument of choosing some form of TAM over a more complex model such at the UTAUT. The paper argues that more complex methods are less parsimonious - that is, the most compact adoption models with the least assumptions should always be preferred, as per *Occam's*

Razor (Van Raaij and Schepers 2008, Siekpe 2010).

There is the added issue with larger models that researchers can suffer with *interviewee fatigue*. This is the phenomenon where potential users being questioned will lose interest or even give up in the later stages of long surveys, meaning smaller numbers of perceived variables, as with more parsimonious models, often give more accurate reflections (Bampton and Cowton 2002).

3.2.2 The Proposed Model

All previous research suggests that choosing one specialised, compact model would the best approach for this project to get useful potential adoption results without suffering from interviewee fatigue or failing to derive meaningful conclusions from overly-complex, perhaps contradictory, results.

With the TAM model being the most prevalent model used in similar literature, and given its relative achievable accuracy against complexity compared to larger models like the UTAUT, it seems the obvious choice as a base model for the project. However, due to the new, unexplored area of this project the IDT stands out as having potential benefits for taking into account the innovation involved, despite the model's limitations.

Therefore, it was decided that conceptualising a new adoption model would be the best way forward, as the existing ones are either too complicated or fail to take into account important aspects of the project. To do this, a base of the TAM model extended with *perceived credibility* (Wang et al. 2003, Luarn and Lin 2005) is appended with a new concept of *social intention to use system*, thus creating the Social Intention Technology Acceptance Model, or simply *SITAM* (Figure 3.5).

Just as the behavioural intention is estimated via perceived usefulness, ease of use and credibility, social intention for each potential user is calculated via their age bracket and an estimate of their *innovative status*.

The only similar approach in the researched papers was by Luo et al. (2010), who also tried to get a measure of the disposition of the interviewee by quantifying their inclination to trust in life to gain an insight into their predicted initial trust of a new system. The approach of the social intention metric is also used to attempt to give a reading of initial system take-up, with the difference that the underlying reason for its inclusion is to ensure that the product caters for those of an innovative disposition.

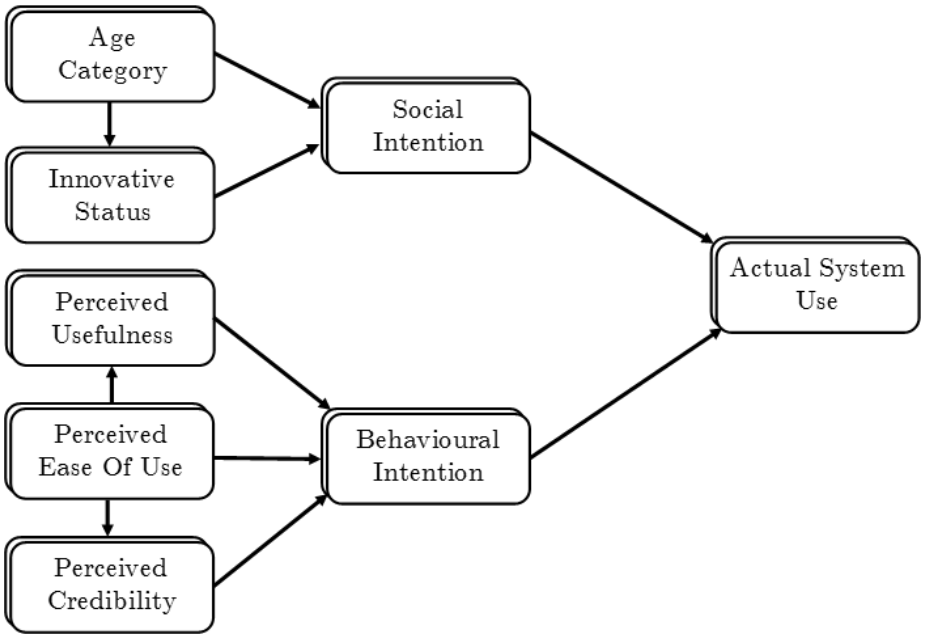

Figure 3.5: The SITAM

Age

The willingness of users to adopt a new technology has been found by several studies to be strongly correlated to age - younger users are more likely to adopt innovations and more likely to have an online social presence (Suoranta and Mattila 2004, Oliveira et al. 2014, Morris and Venkatesh 2000). With personal opinions seemingly harder-hitting than facts in this modern post-truth society, the effects of social media and personal recommendations may prove crucial for the product's successful spread.

Innovative Status

The idea of a users' innovative status was extracted from the IDT, where people are split into the categories *innovator, early adopter, late adopter* and *laggard* based on when they adopt a new system (Rogers 2010). The innovative dimension in the original IDT is measured as a continuous time to adopt variable for an individual, the standard deviation of which creates the split of 5 categories seen in Figure 3.6. In the proposed model, this construct is reformatted to provide an estimate of innovation prior to the release of the new product to aid the adoption rate.

By using former innovations from recent years that later took off into the mainstream as benchmarks, potential users can be bracketed into one of these categories via the time at which they adopted that technology, and their perceived opinions on adopting new

technology. Whilst there will likely be visible relationships between social intention and perceived usefulness, much as there is between that and credibility, this has been left off the initial model until quantified data has been passed through and shown to correlate to these relationships.

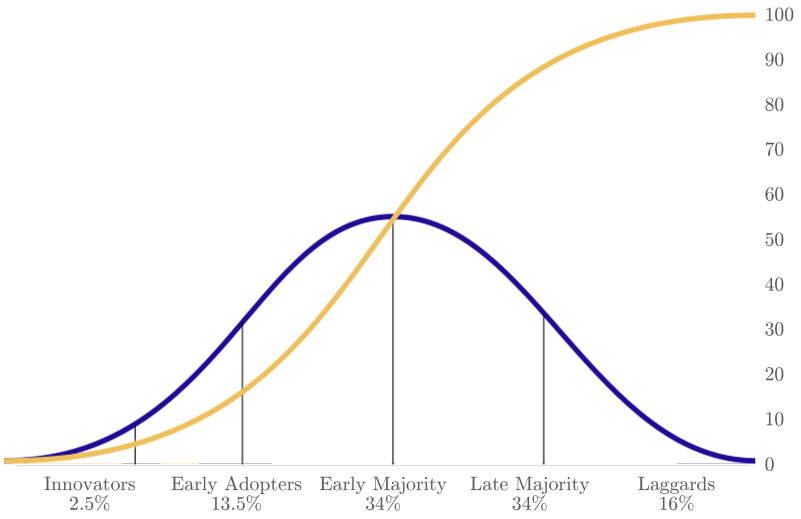

Figure 3.6: The IDT graph: innovator category against percentage of market share showing that with successive groups of consumers adopting the new technology (blue), market share (yellow) will eventually reach 100% saturation level (Rogers 2010)

Social Intention

The perceived social intention can thus be used in a two-fold manner in research for new innovative products. Firstly, there is the assumption that if people were previously early adopters of now-successful products then they will likely have a higher initial adoption rate for new innovations than those who are usually later adopters.

Secondly, in an approach not previously executed in related research, the social intention status of potential users can be used to prioritise their opinions and relatively diminish those of laggards. This exploits the innate app functionality of modern smartphones that previous research approaches have thus far failed to appreciate: the ability to push updates.

With innovation diffusion theory based upon requiring innovators to adopt a new system for it to spread onwards via their social interactions, designers can use this knowledge to maximise adoption at each stage by taking the opinions of each group into greater accounts at each timeline segment of the IDT curve (Figure 3.6). Thus, to begin with in the initial design stage, the requirements of those ranked as early adopters can take weighted precedence over their less innovative companions to attempt maximum possible initial system

adoption. Any different needs emerging from other innovator groups can then be addressed in later updates once an early adopter stage is firmly established.

According to Rogers (2010), the innovator plays a 'gatekeeping' role of new ideas into the surrounding social system: important for launch, but with a less social impact than some later users. In this sense, Rogers decries the early adopter as the character with the "greatest degree of opinion leadership" in social systems, thus being the key part to moving the innovation onto the majority stages (p.249). Due to this, the model proposes equal weighting of these first two categories with gradual decrease for the following three: Innovator - 0.35, Early adopter - 0.35, Early majority - 0.15, Late majority - 0.1, Laggard - 0.05.

This relative diminishing of feature desires by those with a lesser social intention to use the system should work to craft the new system into one with higher adoption appeal for those gatekeepers who have the greatest leadership within the social group.

3.2.3 Model Hypotheses

The Social Intention Technology Acceptance Model (SITAM) will be used with the following hypotheses to gain an insight to the potential adoption and further design of the proposed system.

H1 Social Intention

(a) Social intention will have a positive effect on the rate of actual adoption of the new system

(b) Catering designs disproportionately to the wishes of those with a high social intention will improve the rate of initial adoption of the new system

(c) Younger users will have a higher social intention to use innovative new systems

(d) Past experience in adopting similar innovative products reliably indicates a user's innovative status

H2 Behavioural Intention

(a) Perceived usefulness will have a positive effect on behaviour intention to use the new system (Akturan and Tezcan 2012, p.447)

(b) Perceived credibility will have a positive effect on behavioural intention (Wang et al. 2003, p.509)

(c) Perceived ease of use will have a positive effect on behavioural intention (Wang et al. 2003, p.507)

(d) Perceived ease of use will have a positive effect on perceived usefulness (Wang et al. 2003, p.507)

(e) Perceived ease of use will have a positive effect on perceived credibiltiy (Wang et al. 2003, p.507)

(f) Behavioural intention will directly control the rate of actual adoption for the new system (Ajzen and Fishbein 1975)

H3 Perceived Usefulness

(a) Users with multiple bank accounts will perceive a multi-bank application as being more useful than those with only one, and both more so than users with no bank account

(b) Previous use of price comparison sites, especially for comparing financial products, will indicate a higher perceived usefulness for the new system

H4 Perceived Ease of Use

(a) Perceiving mobile banking and price comparison sites to be easy to use will indicate finding the proposed system easier to use

(b) Belief that managing multiple banks from the new system will be quicker than existing banks indicates perceiving it to be easier to use

(c) Trusting in linking price comparison providers to bank accounts indicates a higher perceived ease of use compared to using providers directly

(d) Trusting in saving money from recommendations correlates to a higher perceived ease of use

H5 Perceived Credibility

(a) Trust of online banking will directly correlate with trust of the new system

(b) Trust of mobile banking will directly correlate with trust of the new system

(c) Trust of third-party banking applications will directly correlate with trust of the new system

(d) Trust of price comparison websites will directly correlate with trust of the new system

(e) Trusting the proposed multibank system less than individual banks will have a negative effect on overall perceived credibility

(f) Ranking security concerns as being the biggest issue with the proposed system will have a negative effect on overall perceived credibility

(g) Trusting the proposed multibank system with price comparison integration less than individual banks will have a negative effect on overall perceived credibility

(h) Trusting the proposed multibank system with price comparison integration less than price comparison websites will have a negative effect on overall perceived credibility

3.2.4 Summary

The TAM is used here to give some level of possible user adoption. Unfortunately, the final *actual system usage* stage of the model is impossible to measure until real, working applications can be developed post the release of PSD2. However, in previous studies (Oliveira et al. 2014) the intention to use was strongly correlated to actual usage.

The new *social intention* section of the proposed SITAM model relies on the basic premise that those ranked as having a higher social intention will both be more likely to use the system and generally have a greater social influence on their network to encourage further adoption by those of a lower innovative status.

3.3 Survey Design

To carry out any user research based on the SITAM model and extrapolate the most desired extra functionality for the proposed system, a survey can be constructed to carefully address each of the SITAM constructs. Success of the model can thus be determined by later comparing the relative adoption rates of the system version geared towards those with a higher innovative disposition against one whose requirements were not influenced by any weightings based on who gave the feedback.

3.3.1 Survey Focus

The survey was therefore formed into two main parts: personal background, and new system adoption. The full question set can be found in Appendix A.1.

Before being informed of any background for the research, an attempt is made to identify the user's age and innovative status, along with indicators that they will find the proposed system useful such as questions about their current banking.

The second page then introduces the proposed system to some degree of explanation and tries to achieve levels of indication for each TAM construct for a base multi-bank application and when adding price comparison features. The final section comprises of feedback on a scale of *actively against* to *not interested* to *very interested*.

3.3.2 Format and Delivery

The questionnaire was delivered via Google Forms for fast distribution, plus easy alteration of questions after publishing if required and automatic exporting of data to spreadsheets

for further analysis.

Feedback sections used 7-point Likert scales to get a good range of values from respondees, requiring them to rate their agreement or disagreement with a number of statements, as had been successfully used in past experiments (Luarn and Lin 2005, Wang et al. 2003, Rogers 2010).

3.3.3 Suitability Testing and Revisions

The survey was given separately to six individuals to give in-person feedback on how they understood each question and topic. This aimed to discover any weaknesses or possible misunderstandings in the way the survey was constructed so these could be addressed before passing onto the majority testers.

Ineffective Approach

In one of these it was pointed out that the approach of using time of innovation adoption from years previously, in this case when they had first bought a smartphone, would be too diluted for the younger student respondents. The suggestion was that financial constraints would likely have been the primary reason for any non or late adoption of innovations in anything but the recent past. On the back of this, the idea of using historical innovation adoption was dropped in favour of adding an element of *self-perceived innovation*. This construct allows users to rate their own level of innovation, and is equally rated with their adoption of the modern (and related) innovations of internet banking, mobile banking and use of Android/Apple pay. It is adopted here on the back of successful use of the similar self-perceived ratings in previous papers, for example Luarn and Lin (2005) gathered positive results when applying the construct of *perceived self-efficacy* in their adaptation of the TAM.

This meant the addition of a further hypothesis to those in Section 3.2.3 to account for the self-perceived innovation.

H1. Social Intention
(e) Self-perceived innovation reliably indicates a measure of a user's innovative status

Age Group Concerns

Another piece of feedback was concerning the original age group rankings of *under 16*, *16-20*, *21-30*, *31-40*, *41-50*, *51-65* and *65+*. One participant commented that 16-18 should probably fall under its own category as under 18's would be unlikely to have sufficient credit for a card, whilst another 21 year old disapproved of being in a bracket up to thirty, requesting a switch to usual brackets of 19-24 to avoid confusion. With this in mind, the

first three brackets were changed to *16-18*, *19-24* and *25-30*, excluding under 16's from the study for similar restriction issues as the innovation question issue of desire but no ability to possess technologies.

Form Affordance Issues

The only other feedback gained was that some of the respondents gave up and left the survey for later on the second page of questions, as there was no indication that it was the final page. There were also issues with the Google Form in showing responses on the 7-point Likert scale on smaller mobile phones, as seen in Figure 3.7.

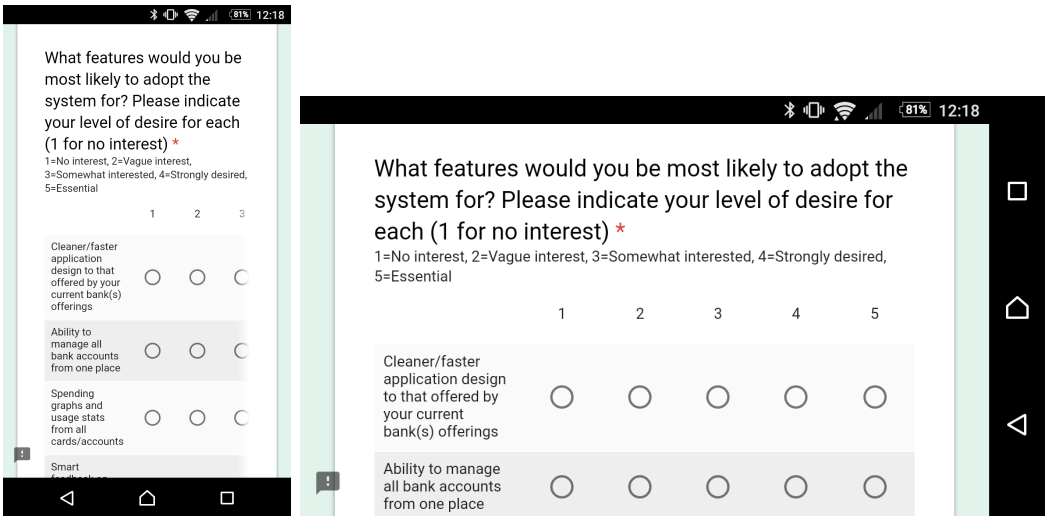

Figure 3.7: Affordance issues in using the form on smaller smartphones (left); on the right the full range is visible when viewing in landscape and reducing to a 5-point Likert scale

To attempt to counter these issues of form affordance and thus optimise response rates, the 7-point Likert was changed to a 5-point for the final question, page numbers were added and mobile users were advised to use the form in landscape mode when answering.

3.3.4 Relation of Survey to SITAM Model

Once the suggested changes were implemented into the questionnaire, with particular reference to the alteration to the SITAM model coming from the addition of *self-perceived innovative status*, the constructs were finalised. Table 3.4 shows the experimental methods of measuring each construct with their related hypotheses for the model (see Section 3.2.3).

Table 3.4: Hypotheses for SITAM Constructs

Construct	ID	Measurement Items	Hypotheses
Social Intention			H1a, H1b
Age Category	AC1	Age Range	H1c
Previous Innovations	PI1	Use of Technology	H1d
Self-Perceived Innovation	SP1	Opinion of general time of adoption	H1e
Behavioural Intention			H2a, H2b, H2c, H2d, H2e
Intention to Use System	IU1	Interested in multibank application	H2f
	IU2	Interested in multibank with price comparison application	H2f
Perceived Usefulness	PU1	Number of banks used	H3a
	PU2	Use of price comparison sites	H3b
	PU3	Use of finance on price comparison sites	H3b
	PU4	Would check price comparison sites before switching bank	H3b
Perceived Ease of Use	PE1	Mobile banking easy to use	H4a
	PE2	Price comparison sites easy to use	H4a
	PE3	Multibank would reduce time taken to manage accounts	H4b
	PE4	Trust of linking price comparison sites with bank accounts	H4c
	PE5	Would trust in saving money from recommendations	H4d
Perceived Credibility	PC1	Trust of online banking	H5a
	PC2	Trust of mobile banking	H5b
	PC3	Trust of third-party applications	H5c
	PC4	Trust of price comparison sites	H5d
	PC5	Trust of multibank application against banks	H5e
	PC8	Security concerns of multibank application	H5f
	PC7	Trust of multibank price comparison application against banks	H5g

PC8	Trust of multibank price comparison application against price comparison sites	H5h

These questions and their related hypotheses were chosen to attempt an accurate representation of each of the SITAM constructs, using inspiration from previous experiments and adjusting to fit the circumstances for this dissertation. The full question set is seen in appendix section A.1.

3.4 Results

With the survey suitably matched to the model parameters and altered to reflect feedback, it was distributed out amongst peer, friend and family networks in an attempt to gain a prime distribution of demographics from those filling out the survey. The data was then taken from the Google Forms platform for analysis of its suitability, reliability and fit to the model.

The full set of raw results from the survey can be seen in Appendix A.2.

3.4.1 Demographics and Social Intention

Perhaps inevitably due to the university-based nature of the project, the majority (72%) of the 68 respondents were within the 19-24 age group category (Table 3.5). This is certainly a limiting factor when analysing the responses, especially in terms of the age group contribution from the SITAM model. However, there were sufficient responses across social intention groups to confidently continue with the study at this stage and analyse results.

Table 3.5: Demographics of Survey Participants

Age	Freq.	Innovator	Early Adopter	Early Majority	Late Majority	Laggard
16-18	0	0	0	0	0	0
19-24	49	5	15	22	7	0
25-30	4	1	1	2	0	0
31-40	5	0	1	4	0	0
41-50	3	0	0	0	2	1
51-65	6	0	1	1	2	2
66+	1	0	0	0	0	1
Totals:	68	6	18	29	11	4

As can be seen from Table 3.5, despite the overarching youth clearly visible from the demographic analysis, the innovative statuses calculated from a mix of self-perceived and previous innovations appear to give sufficient data for continuation of the project.

3.4.2 Analysis Methods

As in previous studies (Akturan and Tezcan 2012, Chin, Marcolin, and Newsted 2003, Siekpe 2010, Kim, Ha, and Park 2015), Cronbach's Alpha calculation (Cronbach 1951) was carried out on the results to determine a measure of internal reliability for each construct of the SITAM model. This is a measure of the squared correlation between observed and true scores, with an α value below 0.3 indicating insufficient construct reliability (Kim, Ha, and Park 2015).

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Cerny and Kaiser 1977) was also utilised to assess the suitability of sampling data, with an index ranging from 0 to 1 with 0.5+ considered suitable for further factor analysis (Williams, Onsman, and Brown 2010).

The results from the analysis of the dataset with question factor loadings (FL), mean and standard deviation (SD) with construct α and KMO values are listed in Table 3.6.

Table 3.6: Statistical analysis of results

ID	FL	Mean	SD	Cronbach's α	KMO
Social Intention				0.695	0.639
A1	0.702	0.847	0.281		
PI1	0.829	0.632	0.241		
SP1	0.831	0.397	0.221		
Perceived Usefulness				0.658	0.626
PU1	0.563	6.074	1.489		
PU2	0.846	4.441	1.919		
PU3	0.685	2.941	2.828		
PU4	0.707	4.162	1.850		
Perceived Ease of Use				0.427	0.525
PE1	0.779	5.382	1.446		
PE2	0.780	4.971	1.327		
PE3	0.851	5.000	1.684		
PE4	0.713	2.691	1.595		
PE5	0.611	4.750	1.274		
Perceived Credibility				0.578	0.634
PC1	0.565	5.875	0.968		
PC2	0.776	5.156	1.556		
PC3	0.727	2.844	1.535		

PC4	0.559	4.328	1.574		
PC5	0.680	2.750	1.285		
PC6	0.709	2.328	1.604		
PC7	0.751	2.813	1.332		
PC8	0.628	4.391	1.580		
Intention to Use				0.768	0.5
IU1	0.898	4.515	1.671		
IU2	0.898	4.618	1.779		

Once reliability of constructs and sampling data was established, Partial Least Squares (PLS), a component based structural equation modelling (SEM) technique, was used to analyse the proposed hypotheses and provide component values to the SITAM model (Luo et al. 2010). Other models used in related literature, such as the LISREL summation scale (Jöreskog and Thiilo 1972), can reduce measurement error but are "suboptimal relative" to PLS due to PLS treating each indicator separately, allowing each to contribute different estimated construct influences (Chin, Marcolin, and Newsted 2003, p.194). PLS is also marked as suited for experiments during the formative stages of theory construction and testing (Jöreskog and Wold 1982). This makes it ideal for use within the dissertation to formulate useful values for hypotheses on the proposed model, with both the subject and the adoption model itself being innovations in the research space.

PLS Results on the Model

When compared to the IDT graph (Figure 3.6), it can be seen that the participants, likely due to their average youth, are pushed down towards the innovative end of the scale (Table 3.7).

Table 3.7: Relative population samples from Innovation Diffusion Theory and the acquired questionnaire data

Innovative Status	IDT assigned population	Results population
Innovators	2.5%	8.8%
Early Adopters	13.5%	26.5%
Early Majority	34%	42.6%
Late Majority	34%	16%
Laggards	16%	5.9%

The relative lack of representative sample population at the *late majority* and *laggard* end of the scale may also be a result of the type of people asked to complete the survey. This group included fellow Computer Science students and former co-workers within a technology division, as these are likely to be people with a more adoptive attitude to technology than the general public, which when mixed with low average youth could explain the gen-

erally innovative-weighted sample, as opposed to placing fault upon the measures used to estimate each respondent's innovative status.

This resulted in the modified SITAM as in Figure 3.8; the age category is now integrated into the innovative status calculation with previous use of technology and self-perceived innovative status. The social intention/innovative status has strong correlations from all three, as seen in the graph.

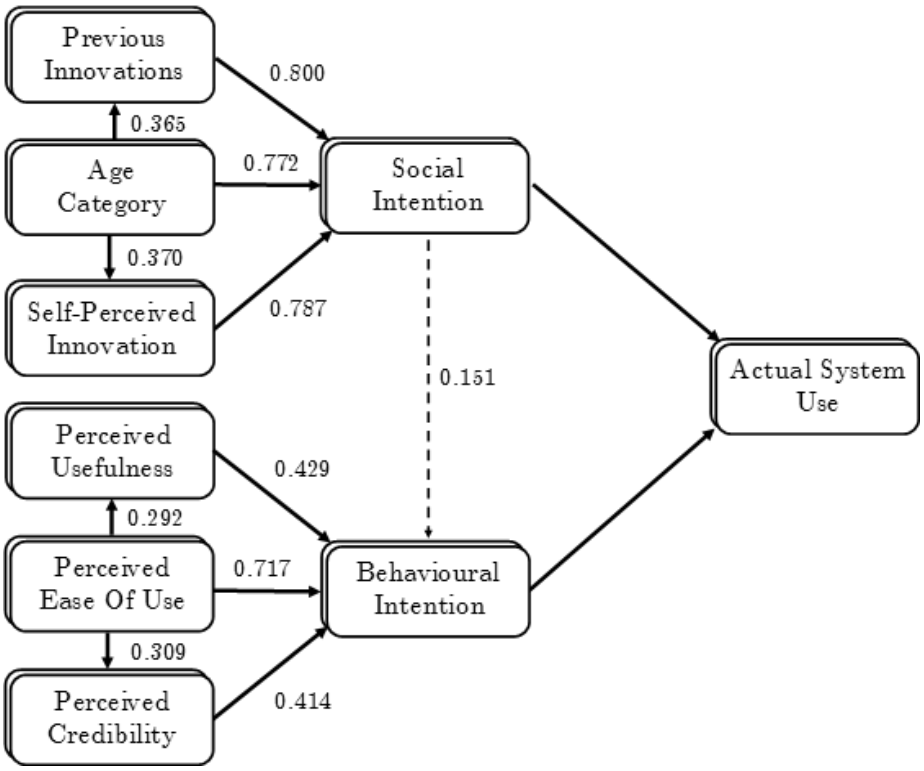

Figure 3.8: Modified SITAM with hypotheses testing results via PLS analysis

Unlike findings by Wang et al. (2003) or the similar subsequent research by Luarn and Lin (2005), the *perceived credibility* metric did not achieve a higher PLS factor value than *perceived usefulness*. However, at at **0.414** it was a significant contributor for users intending to use the system and a slightly stronger relationship then found by those two studies. This could possibly reflect the addition risk of managing personal finance via a third party system, compared to the **0.24** result for internet banking (Wang et al. 2003) and **0.36** for mobile banking (Luarn and Lin 2005).

The significance of *ease of use* on the usefulness and credibility factors was notably smaller than on the aforementioned studies, at **0.292** and **0.309** respectively compared to values

around **0.7** and **0.65** in those papers. The calculated figures however were very similar to those found by Karjaluoto et al. (2010). This could potentially be down to that study's focus on young consumers, much like the very youthful demographic apparent in the participants of this survey, which suggests ease of use of technology may be a less important factor for younger consumers.

Perhaps surprisingly, when calculating the PLS value for *Social Intention* (represented as a dotted line in Figure 3.8 due to their lack of connection within the model hypotheses) the value is only **0.161**. This indicates a low relation of innovative status to actual intent to adopt the new system, meaning that innovative consumers are not significantly more likely than others simply through this attribute. Though it could be reasonably expected that innovators would be more likely to adopt a new system like this, it makes the effects of feature aiming for different innovator groups even more crucial to attain the adoption levels of innovators needed to diffuse through to adoption by other user groups.

3.4.3 Desired Features

This sections contains a ranking showing how each feature was perceived with and without the weighted opinion rankings based on the social intention rating acquired by given user. These will then be used the fuel the scoping and creation of requirements for systems aimed at the members of different innovation groups.

Primary Requirements

The main features as desired by responders were measured on a 5-point Likert scale from 1, *not interested* to 5, *essential*. This allowed a thorough measuring of the extent to which persons from each innovator category were interested in each possible system attraction.

As can be seen in Figure 3.9, when using the weightings of number of respondees the adding further weightings based on the innovative category as defined previously (0.35, 0.35, 0.15, 0.1, 0.05) made little difference to the preferences. This is arguably due to the poor spread of respondents in terms of demographics (Section 3.4.1), however this can be addressed by looking at the raw data averages per innovative category without the population weighting.

As seen in Figure 3.10, there are considerably different feature priorities for those of category 1, the innovators, to the laggards of category 5, with middle categories (which 85% of respondents fell into) reporting very similar average desires. With these middle groups also reporting similar average *intention to adopt* values (4.61, 4.34, 4.63 compared to 5.58 for innovators and 4.25 for laggards) it can be argued that the main factor for when persons of the middle groups adopt the system would be their relative access to those who have already adopted and can recommend - to start with, the innovators.

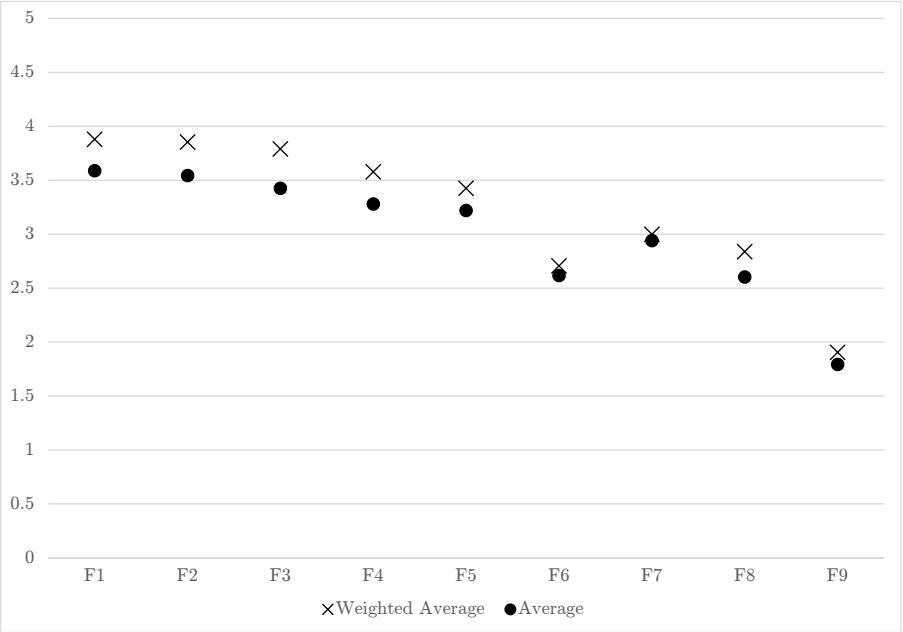

Figure 3.9: Average weighted with responders per innovative category and with added category weightings

Innovators have, on average, given higher desire values for every available feature than the laggard group. Because of this, to get a set of two designs with sufficient feature variance for future testing, the top three desired features were chosen from each to be prioritised within their respective application designs.

Thus, as seen in Table 3.8, laggards were found to prioritise the core application features of providing a multi-bank mobile application and incorporating price comparison. Innovators meanwhile also had price comparison integration in their top three, but the first two focused on smart feedback and spending graphs. This could highlight an ignorance of the core provisions of a banking app in favour of innovative new features that they may not currently get from their mobile banking experience.

Figures 3.9 and 3.10 show that the least preferred feature overall was F9; the linking of personal finance informations to advertising profiles to potentially improve the quality of targeted advertisements when browsing. This gained a mean score of just 1.8 out of 7 across all 68 responses and the second lowest mean deviation meaning low scores were very general across all responses. This is likely due to the security and ethical concerns involved with selling financial information to advertising companies.

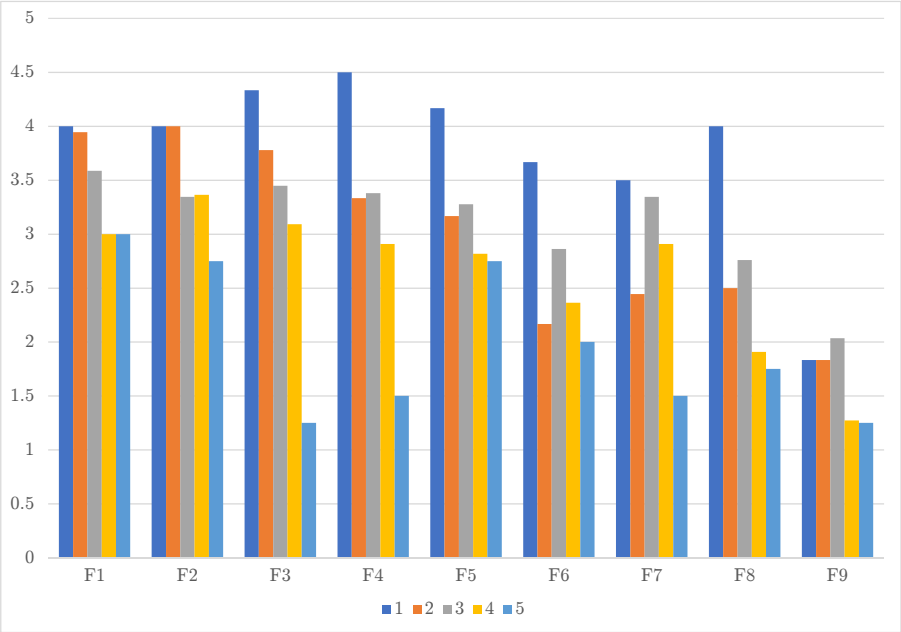

Figure 3.10: Average ratings on 5-point Likert for the 5 innovation categories (1 = Innovator, 5 = Laggard)

Table 3.8: Highest scoring desire requests for innovator and laggard responses

Ranking	Innovative Feature Choice	Laggard Feature Choice
1	F4: Smart feedback on spending habits	F1: Cleaner/faster bank management design
2	F3: Spending graphs and visuals from all accounts	F2: Ability to manage bank accounts from one place
3	F5: Price comparison integration for money saving suggestions	F5: Price comparison integration for money saving suggestions

Notification Method

One key consideration for the application was how users would want potentially money-saving offers to be advertised to them. The options given for this are seen below.

1. Occasional 'push' notifications that appear on your smartphone to inform of new recommendations
2. Occasional 'push' notifications that appear on your smartphone but stop for a number of months after enacting one of the recommendations
3. 'Weekly roundup' notification

4. Recommendations only given when going on a special page on the application

From these options, responders were asked to pick only one as their preferred option, as opposed to rating their respective preference on a Likert scale.

Similar to the features, when integrating the weightings for population size, the additional model assigned ratings dependant on innovative status make little difference to the overall graph (Figure 3.11).

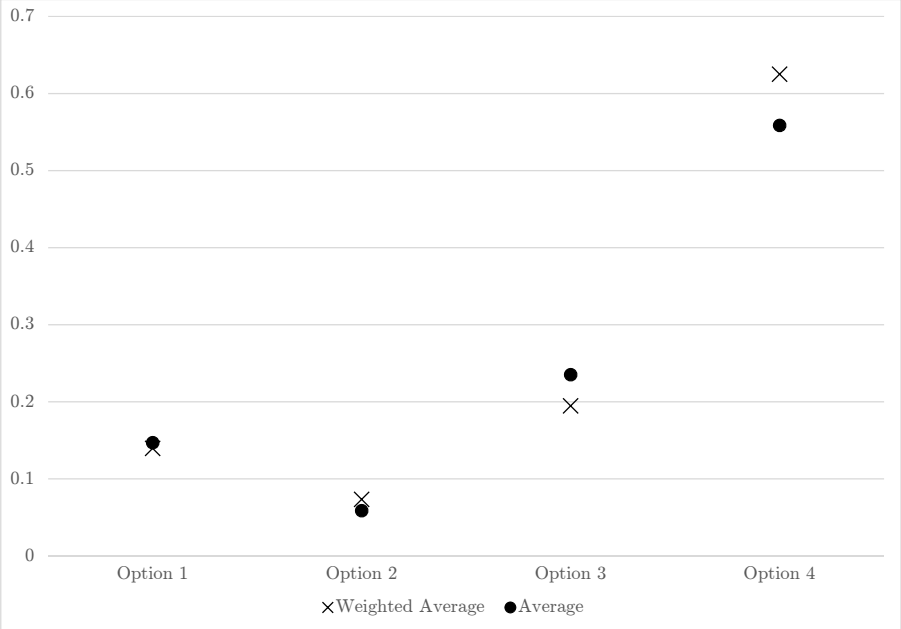

Figure 3.11: Average weighted with responders per innovative category and with added category weightings

However, the raw results as seen in Figure 3.12 show a large difference between the notification style preferred by the different ends of the status scale. Innovators strongly clustered to the *special page in application* option, with 67% opting for this method. Meanwhile, 75% of laggards chose having *push notifications* as their preferred delivery. This difference of opinion could be down to a number of factors; perhaps more innovative people have adopted more mobile applications in general and do not wish to get even more push notifications on a daily basis.

3.4.4 Additional Comments

The additional comments or requests section at the end of the survey was introduced to allow suggestions by the respondents, with the field being the only free text input within the

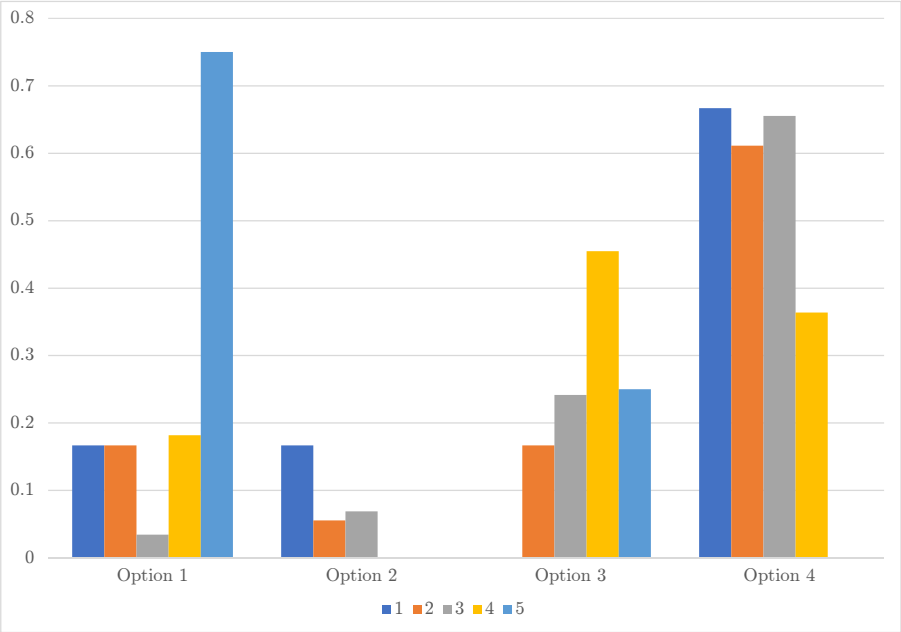

Figure 3.12: Chosen notification options for responders for the 5 innovation categories (1 = Innovator, 5 = Laggard)

question set. This brought few responses, but some useful suggestions of extra requirements that could be integrated into the system.

Security

There were four different comments related to security from this section. Three of these were concerned about the level of security and suggested they would avoid adopting unless there was some trust in the system, with one in particular requesting some 'confirmation of security' for the application from banks, if possible. The other requested easy access to the application, potentially via fingerprint scanning.

Such security measures were omitted from the questionnaire as the PSD2 regulations have yet to state the exact mechanisms that will be required for third-parties to gain access to accounts, however the current two-factor authentication requirement means that fingerprint-only access would be not be feasible.

Others

Other requests consisted of desired features for the application, including smart cashback statements, notifications for when intra-account transfers have completed and the ability

to clearly see all aspects of when personal data is exported to third parties with the ability to turn each one off individually. Whilst the first two of these would likely depend on the features that certain banks allow through their API calls, the third is certainly one that could be integrated into the system for optimal transparency to consumers - and plausible deniability should any complain about their data use at a future time.

3.5 Concept and Requirements

The next stage is to integrate the different sections of research and first-hand findings to fully conceptualise the proposed system before moving onto the next stage, development. Using a mixture of the essential basic requirements as perceived from successful existing banking apps and the additional features most desired by interviewees, a full system concept and set of requirements can be created. This full set of requirements can henceforth be the primary measure of development progress and overall success for the project.

The keywords **must**, **should** and **could** indicate whether the requirement is essential or not for the completion of the study. Requirements listed **FR** are Functional Requirements, with **NFR** indicating Non-Functional Requirements.

3.5.1 Project Concepts

A set of requirements initially conceived in the project proposal to provide a measure of success for the primary aims of the research.

FR1 **Must** design multiple user interfaces to get user feedback

FR2 **Must** create a working prototype allowing user testing

NFR1 System **must** provide a novel method of personal finance interaction

NFR2 Project **should** offer a useful set of guidelines for future research and development

NFR3 Project **should** encompass a suggested moral code for future developments

NFR4 Guidelines **should** suggest alternative systems for development

NFR5 Designs **should** be accessible to users from a wide variety of technical expertise

3.5.2 Core Banking Features

The early research into banking applications by Pousttchi and Schurig (2004), as discussed in 2.1.1, came up with only four use cases that study groups of the time could decide

upon. As basic and expected as they are in modern applications, the concepts could be taken as the basis of what should be achievable in this application in order to function as a cross-bank management system. This is an important scoping issue, as though most modern banking applications offer a number of other features it may prove almost impossibly complex to attempt to offer each of these in a global application like this (eg. opening new accounts, etc) as the API's to access these features will likely not feature under final PSD2 regulations and thus remain non-standardised. Therefore, these use cases remain an achievable set of targets to get users to adopt this system as their banking app on a daily basis, which is key to expose deals to them if the final application does not feature push notifications.

Requirements for the four primary use cases as defined by Pousttchi and Schurig (2004).

FR3 **Must** administer account balance requests

FR4 **Must** allow control of account movements

FR5 **Must** provision instant payments

FR6 **Must** permit account administration and transaction execution

Elaborating on these core requirements are the features found within the most highly coveted two banking applications available from high-street banks in the UK in 2016, Lloyds and Barclays (Section 3.1). In order to properly compete with these and gain market share, the new app should aim to achieve equal functionality.

FR7 **Should** give full transaction history and searching within this

FR8 **Should** allow direct debit and standing order management

FR9 **Should** provide an integrated map for finding ATMs

FR10 **Should** provision executing P2P payments

FR11 **Could** provide an offers and/or cashback rewards page in the app

FR12 **Could** provide a means to report cards lost or stolen

FR13 **Could** allow Android and Apple Pay through the app

The final three here are set as **could**, as they may not be achievable in a final application. The offers and reporting cards stolen features are questionable due to not knowing if these features would be available through bank's APIs. Meanwhile, the Android/Apple Pay may not be possible due to the current PSD2 specification requiring two-factor authentication to access account features, where one of the base attractions of these technologies is to purchase items with only single-factor fingerprint or pin-based security on the device.

3.5.3 Questionnaire Requirements

Requirements are derived from the quantified results of the questionnaire in terms of the feature options, notification style and any additional suggestions.

Features

The top three features chosen by each innovator category are enshrined as **must** requirements when they represent the core features of the system, and **should** where the features were highly rated but not completely indicative of achieving the overall project vision.

FR14 **Must** provide money saving suggestions via price comparison service integration

FR15 **Must** allow users to manage multiple bank accounts from within the application

FR16 **Should** give a cleaner/faster bank management design to current banking apps

FR17 **Should** provide smart feedback on spending habits

FR18 **Should** visualise account details and spending graphs

NFR6 Innovator-focused design **should** give prioritisation and focus to smart feedback and spending graphs when entering the application

NFR7 Laggard-focused design **should** give prioritisation and focus to essential account management functionality

Notifications

As discussed from the results of the questionnaire, the laggards opted for push notifications as their preferred choice whilst innovators strongly opposed having another push notification based app on their phones, opting for only seeing these when already within the system.

This may act as a blocker for displaying money-saving deals, but research by Barclays (BBA 2015) found that active mobile customers accessed their app an average of 28 times per month in 2015. This suggests that, as long as the new system can replace user's existing mobile apps completely for their everyday account management, they will access the system regularly enough to see notifications without needing to implement push notifications and potentially frustrate users into uninstalling the app.

FR19 Innovator-focused design **must** provide notifications only through a special page within the application

FR20 Laggard-focused design **must** provide push notifications for deal alerts

Suggested Features

Potential requirements derived from the additional features comment section in the survey that could be implemented into the designs.

FR21 **Could** provide an options page allowing users to manually control all instances of data exports to third parties for processing

NFR8 **Could** investigate getting bank-backing for the security credentials of the application in future

3.5.4 Ethical Considerations

With such little precedent over how much is too much in terms of the extent of data mining repercussions, a discussion is needed over the scope of what to extract from the app. The key ethical issue is the amount of data that can be available to effectively sell for referral commissions to the price comparison providers, with considerations for the extent to which customers can be notified of offers in an attempt to persuade them.

Requirement FR21 touches on this more exactly by suggesting users should be able to control all data movement out of the app. With this in mind, a requirement should be added to deal with user knowledge and understanding for the public release of the system.

NFR9 **Should** ensure sufficient understanding in users of how and why all personal data will be mined and utilised

3.6 Summary

This section of the project was first informed by investigating the most popular banking apps currently available in the UK via store reviews and blog mining. These combined to reliably identify the best rated two apps to influence the design and creation of the new competing system.

Following research into technology acceptance modelling, a new adjustment to the Technology Acceptance Model was developed with influence from Innovation Diffusion Theory. This was introduced due to existing methods failing to properly model a modern update-driven application lifetime, with IDT methodology allowing developers to maximise theoretical adoption levels by focusing the app initially only at users of an innovative disposition. They then diffuse this adoption onwards to other groups. Exposition of the state of the art was here achieved via the new way of integrating the ideas of IDT (Rogers 2010) into the

TAM model, in particular with the proposed new way of quickly and concisely predicting a survey participant's level of innovation.

Theorising a number of hypotheses for the model allowed creation of suitable measurable metrics within to aid the creation of a short survey to collect data for the base TAM factors, the innovative status of the participant and their primary requirements for the proposed system. The survey was then successfully distributed to gain a reliable dataset from the 68 respondents, from which distinct feature requirements were extracted for opposite ends of the innovation spectrum.

The next *Design and Prototyping* chapter will detail the conceptualisation of separate innovator and laggard targeted system designs based on the requirement sets derived from the survey data. After rounds of improvement, the innovator design will be taken as the system template when developing a working system for smartphone deployment and testing.

Chapter 4

Design and Prototyping

This chapter will focus on taking the requirement sets for the *laggard* and *innovator* targeted systems resulting from the user adoption results and developing fully-fledged prototyped designs for each. First up, wireframe models of potential application layouts will be created to meet the requirements and primary use cases of each model, before evolving into high-fidelity interactive prototypes based on user feedback.

Once these are evaluated, the *innovator* design will be used as the base model when developing a viable Android-based system for further evaluation.

4.1 Design

With requirements for the two distinct products, the design stage for each could begin. The creation of the two prototypes should represent the differences found between the wants and needs of the two groups, before the innovator-targeted design is taken on as the concept for system development.

The process will take inspiration from existing banking applications and common design paradigms, using these to construct attractive yet functional designs that focus on meeting the primary use cases. Initial low-fidelity wireframe mockups will be analysed separately by members of the adoption group they are aimed at to establish targeted designs. The feedback from this will guide the construction and further casual analysis of high-fidelity interactive prototypes to perfect application specifications for each group.

4.1.1 Realisation of the Requirements

The key focus of the design process must be to encompass the requirement sets and primary use cases into usable interfaces, with special attention given to address the bulk of the **must**

labelled requirements. One of the key aspects of good UX design is to ensure maximum *recognition not recall*; that is, to attempt to design the system such that information is clearly transferable between views and easily retrievable (Nielsen 1999).

4.1.2 App Design Research

With respect to meeting the primary use cases and fulfilling the requirements set out for each system, the appearance and usage patterns of the designs must be established and reviewed by the relevant potential users. For appearance, the *Lloyds* and *Barclays* apps - identified as the most popular banking providers in the UK (Section 3.1.4) - were used as influence for creating some of the initial designs. The *Mint* user interface was also used as a reference point due to its standing as the most popular account aggregator on the world market and its utilisation of spending related graphics, as these were marked by the survey as a key innovator desired feature. Finally, general user design paradigms such as Android's *Material Design*[1] should be kept in mind throughout the process in an attempt to encompass known best practices for mobile applications into the new system.

4.1.3 Low-Fidelity Prototyping

Some low-fidelity wireframe modelling was initially used to harvest user feedback for screens emulating the general look and feel of a banking app, Mint, and simplified Material Design.

Design Options

An an example of choices given, the three main proposed designs for the accounts screen are seen in Figure 4.1.

These sketches helped to give the participants an idea of the basic layouts, with the arrows connecting screens to show how they would interact with the finished system.

4.1.4 Analysis

The feedback from the innovative participants liked a mix of the Android and Mint style, getting a card-based structure for the Splash screen and graphical interface to represent accounts. The laggards were less influential, failing to conceptualise and suggest changes like the mixing of different styles to essentially choose the Lloyds/Barclays influenced design, dismissing the graphical Mint screens as too complicated.

[1] https://material.io/guidelines/

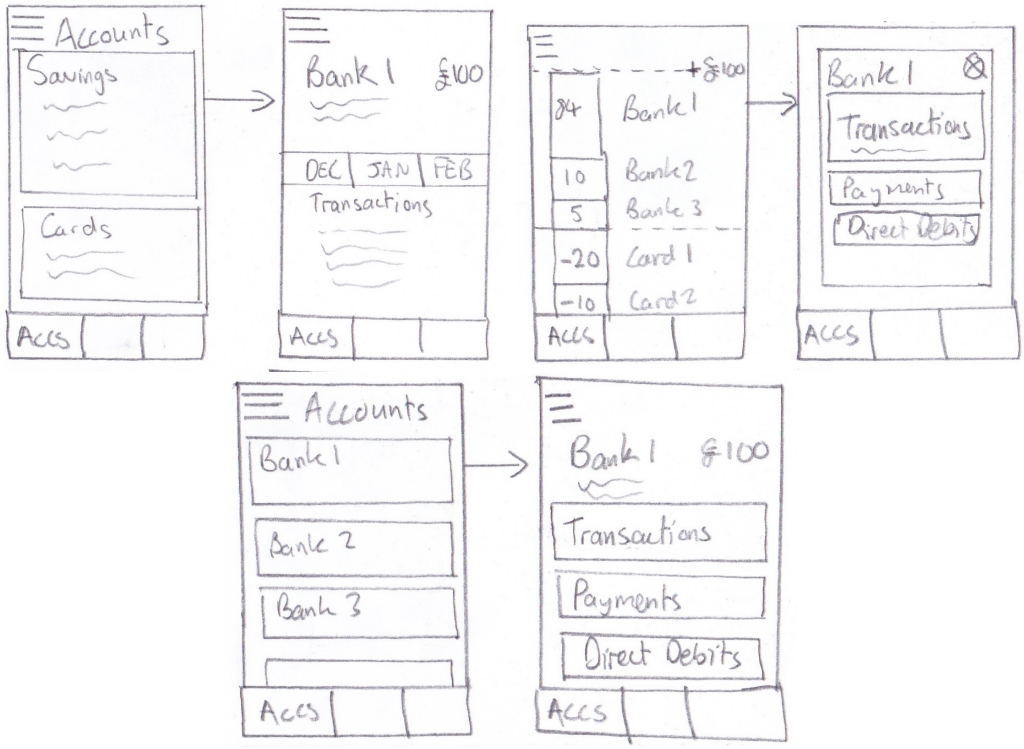

Figure 4.1: Three accounts taking influence from banking apps, Mint and simplistic Android design

4.1.5 High-Fidelity Prototyping

The feedback from the low-fidelity wireframe part of the design process led to the creation of two high-fidelity prototypes to embody each system. *Balsamiq Mockups* was used to conceptualise the proposed applications, with the more detailed design and linking of pages via interactive buttons giving potential users a useful insight into the way the systems can be navigated. *Balsamiq* also seemed ideal due to its cartoonish style, as research has previously suggested that more refined or 'finished' designs can discourage users from giving the same level of feedback as they otherwise would have for an apparently less developed system (Sauer and Sonderegger 2009).

Innovator-aimed Prototype

The three primary page designs of the innovator-aimed high-fidelity model are seen in Figure 4.2. The entry *splash* page contains a number of cards containing a mix of price comparison offers, useful account information such as spending habits and of features like the ATM finder. The *offers* page is similar, showing only offer cards but otherwise having the same click to enlarge or dismiss functionality. This card design was picked from the

low fidelity options as being the most effective for representing this information, and gives a valuable similarity to other common Android applications.

The accounts screen utilises a visual cue for instant recognition of the overall state of finances over all accounts imported into the system, with colours used to indicate whether the account is in credit or in debt. Selecting these bars would then give more account details and allow further actions through that bank.

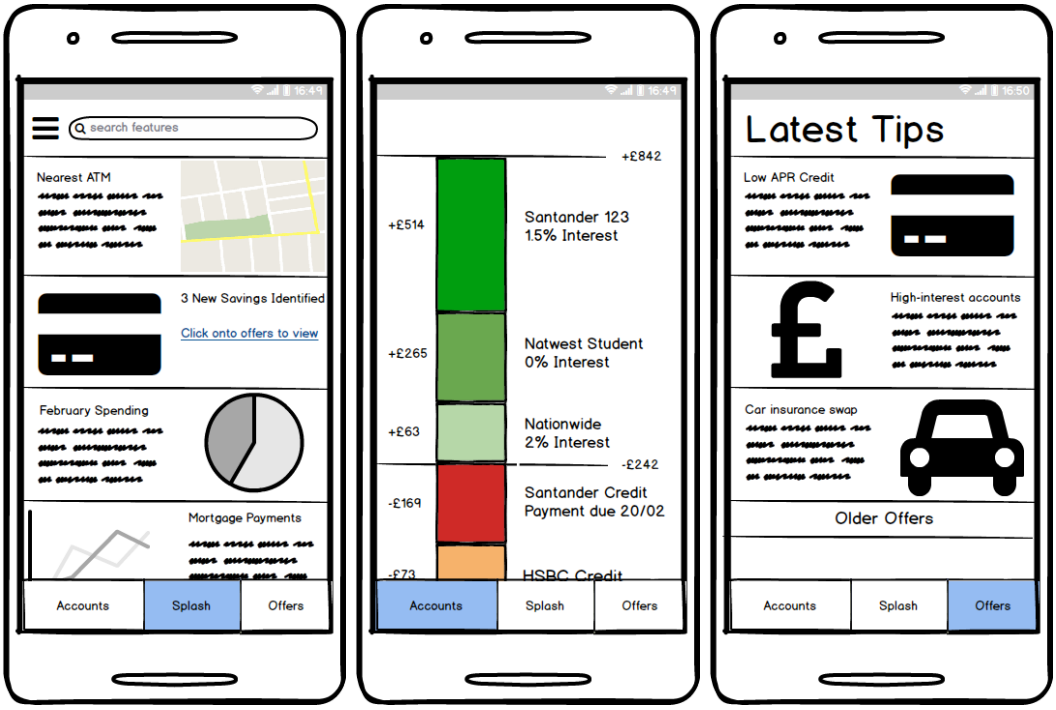

Figure 4.2: Main innovator application screens

Laggard-aimed Prototype

Whilst the laggard screens (Figure 4.3) are largely similar in content to the innovator's, the general design and navigation had some changes. One of the main differences between the two concepts needs to be the application entry point; into a general splash page containing offers and finance details for innovators, compared to straight into an accounts summary screen for laggards. This initial accounts screen is also much more like a traditional mobile banking app than the graphical representation preferred by the innovators.

The offers screen is the same, but with the laggards preferring to have notifications for offers, users of the laggard system can also enter the app directly into one of the offers via a notification link.

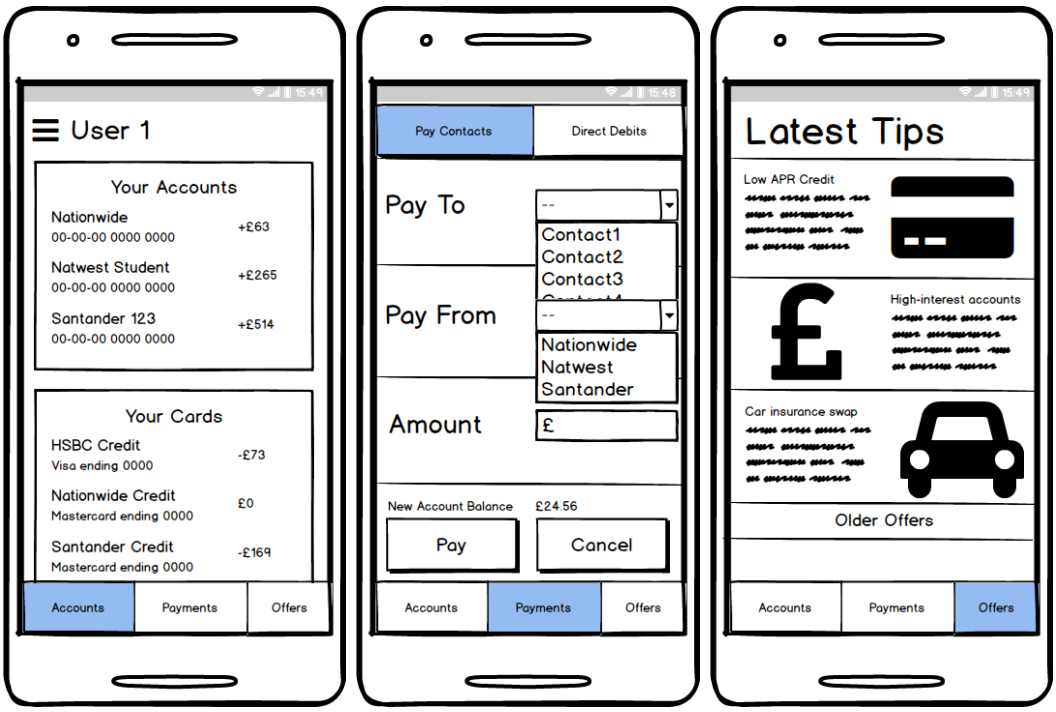

Figure 4.3: Main laggard application screens

4.1.6 Analysis

Much as in the low-fidelity design period, there was little useful feedback for the laggard prototype; this set of form layouts is therefore concluded to be the ideal for the user group. As such, these are left aside for enacting at some point in the future when the application has achieved real-world user adoption by the other innovative status groups.

In terms of the innovator design, there was some feedback to be incorporated into the next stage of development. This included a desire to not have scrolling in the accounts screen, instead preferring to have the negative accounts side-by-side with positive in order to fit all on one view. There was also the request for accounts to include a general 'total funds' type indicator when first entering the page, before being able to select the detail from specific accounts.

There was also a lack of understanding for the need of the search on the splash screen and, as this dynamic help feature falls out of scope of the essential requirements, it can be dropped for the next section.

It would have been better to get quantifiable feedback during this stage for making im-

provements, but the limited participants available for feedback in the *laggard* and *innovator* groups led to choosing an informal spoken method of collecting data, as any dataset would have been too small to give reliability. This does mean that the small adjustments to the designs suggested by participants may not be representative of their status group as a whole, but as none of these changes were particularly drastic it was deemed that some feedback and assistance in sculpting the requirements into tangible designs was too valuable to discard.

4.2 Development

The next step was to develop a working Android application based on the innovator requirement specification and subsequent prototyped designs. This uses the influence of Innovation Diffusion Theory and its integration into the SITAM to create a product with the theorised best initial adoption attributes and thus overall ongoing market share growth.

4.2.1 Approach

As discussed in section 1.1.3, the Android operating system was chosen as the development environment in the project. Though the created app will not function as eventually intended by connecting to banks, due to it being developed prior to the release of PSD2, it should utilise mock data as if it were real. This should then appear to users as though the app is fully functioning, whilst enabling easy 'plugging-in' of the security features and API requests when details of such are released.

4.2.2 Method

The approach taken to create this easily expandable design was to use a segmented package structure and utilising the *Dagger 2*[2] dependency injection library to handle object instances throughout the application. Interfaces were also used through important logic units including those sourcing the currently mocked-out data so that these could be simply swapped out for functioning units connecting to external data sources in the future without widespread code disruption.

The newest Android 7 (Nougat) SDK was used as the base toolset in order to get the latest supporting features and allow the use of some Java 8 functionality using the *Jack toolchain*[3]. Though Nougat currently runs on just 2.8% of devices[4], this will likely be much higher come any public release of the app sometime after January 2018 and as such using the latest version seems a prudent way of future-proofing the system codebase. Another

[2]https://google.github.io/dagger/
[3]https://source.android.com/source/jack.html
[4]As of 7th March 2017 https://developer.android.com/about/dashboards/index.html

reason was the potentially likely requirement of running only on newer Android versions that PSD2 could impose on third party providers when full security details are released.

For graphs within the application the opensource *Hellocharts*[5] library was chosen out of several available due to its popularity and the existing integration of stacked bar charts, as this appearance was identified via prototyping as the ideal account representation. As well as stacked bars, pie charts for a spending habits breakdown and combo line and bar charts for monthly income vs. outcome were utilised from the library.

4.2.3 Result

The end result looked to emulate the well-received *innovator* high-fidelity prototype in functional form, with one or two small alterations based on the final round of feedback. Figure 4.4 shows the primary three screens of the application; the card based *splash* and *offers* tabs plus the graphical *accounts* page.

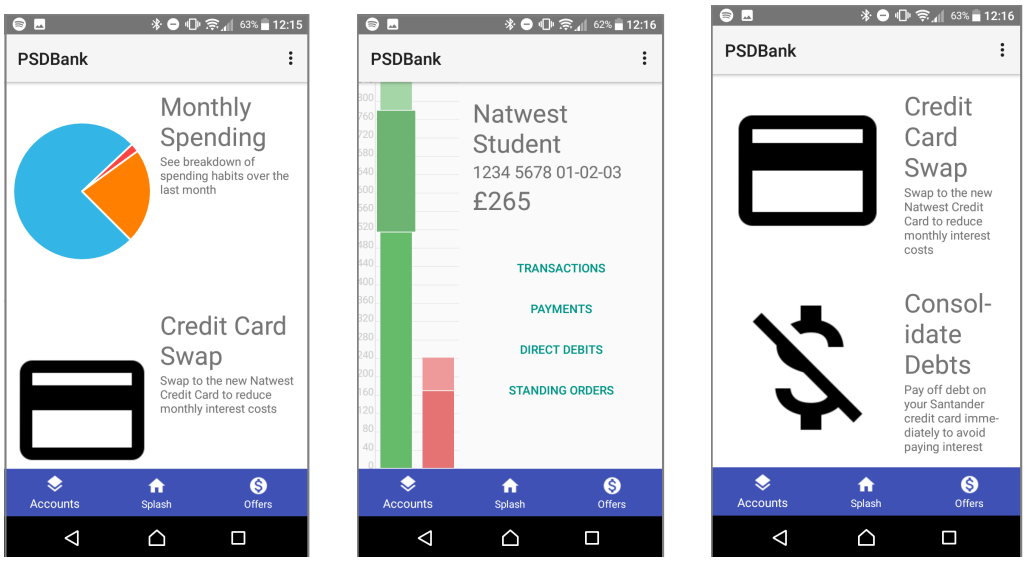

Figure 4.4: The created login, splash and options screens

The accounts page differs slightly from the prototype based on requests that all accounts be visible on a single screen without requiring scrolling down to see indebted accounts, as in Figure 4.2. Other than this, the designs were largely copied as closely as possible, with the splash page including a randomly ordered set of spending graphs and new offers that could be clicked to enlarge and interact with. The full set of screenshots from the application can be seen in Appendix C.1.

[5]https://github.com/lecho/hellocharts-android

4.3 Summary

This chapter of the dissertation was key to transform the theorised ideal requirement sets from the user adoption research into designs and eventual development into a working Android-based application. The prototyping periods helped optimise the end design into one best embodying the wants of the most innovative members of the potential userbase.

The created app is inevitably limited due to having to utilise mocked-out data for the experiments as opposed to presenting a functioning proof of concept. However, the created codebase has been optimised for integrating the required security functionality and external bank connections as and when details of these become available in the lead up to the January 2018 PSD2 release.

To give evidence on the suitability of the created application for appealing to innovators and competing with existing banking applications, the following *evaluation* section will use experimental procedures to investigate these aspects via a user study.

Chapter 5

Evaluation

Following on from the development of the *PSDBank* system, the next step is to critically evaluate the success of the created product in achieving its aims. This next chapter therefore includes the designing of a suitable experiment to test usability against another existing banking application, leading to conclusions on its suitability for the market and the accuracy of the earlier adoption predictions.

5.1 Empirical Testing

The experiment needs to focus on one key aspect of adoption for the potential new system - that is, that it must complete general banking tasks *at least* as well as existing mobile banking solutions in order to gain market share.

To investigate this, and to be able to give a final conclusion of adoption for the SITAM model hypotheses (Section 3.2.3), a comparative usability test was utilised.

5.1.1 Experiment Design

The questionnaire earlier in the dissertation derived the *intention to use system* metric from two questions; one about willingness to adopt a multi-bank system and one measuring willingness to adopt such a system but with an added price-comparison focus.

To replicate this for comparison of how the metrics successfully estimated adoption, a number of 'standard' essential banking tasks were set, with users then timed in carrying out these tasks on the created system and on a real Lloyd's account, as that was derived as the best current UK banking app in earlier research (Section 3.1). Users would then be asked about ease of use comparatively for each system.

With the aim of ensuring fairness, this within-subjects experiment would give half of the test base the Lloyd's app first with the other half getting the created app first. Following on from this comparison round, users will be asked to use the price-comparison 'offers' capabilities of the created application before filling in a short questionnaire to establish willingness to adopt the system.

These results can then be used both to measure the current status of the application in being at-least as good as existing banking applications, and the level of success the SITAM model had in predicting system adoption.

5.1.2 Experiment Hypotheses

The experiment looked to provide evidence for or against two primary null hypotheses:

EH1 The PSDBank and Lloyds apps will have equal usability

EH2 The banking tasks will take participants the same time on both

If there is insufficient significance found in the results to reject these hypotheses then the results can be given in evidence supporting that the new system has achieved its primary aim of being at least as usable as the Lloyds app.

In addition to these, it is expected that by collecting results matching the 'intention to install' metrics from the initial survey, these will be comparatively similar for each participant with their original answers.

EH3 Participants will indicate equal intention to install a multi-bank application as their intention from the survey

EH4 Participants will indicate equal intention to install a multi-bank application with price comparison integration as their intention from the survey

Measuring against this hypothesis should give evidence for or against the effectiveness of the SITAM and original survey in predicting participants potential adoption of the proposed system.

5.1.3 User Base

The user base will ideally be made up purely of people who left their email at the end of the original questionnaire so that their estimated innovation status is already derived with their willingness to adopt the system based only on brief descriptions of its functionality.

The extent of the experiment means those asked will likely be cut down to a maximum of 10, selecting persons from different parts of the innovation spectrum.

To avoid confounding results, users will be asked before beginning whether they currently use or have previously used the Lloyd's banking application, as they would then be considered 'expert' users and subsequently distort results.

A pilot run will be carried out by a volunteer before starting the full round of testing to get suggestions of how to improve

5.1.4 Banking Use Cases

To directly compare the level of level of usability for the new PSDBank and Lloyds applications, the same set of 5 primary tasks were set for each followed by a round of usability determining questions. The usability levels of each can then be measured via the usability score and the time taken to complete each set of instructions. The primary tasks were as follows:

1. Log into the application
2. Check the active balance of an account
3. Inspect recent transactions for an account
4. Initiate a payment from one account to another
5. Re-inspect the recent transactions to check that the payment had successfully transferred

The full instruction set as given to participants is in Appendix D.2. The order of the first two sets were swapped each time to ensure that half of participants used the Lloyd's application first and half used PSDBank first to counteract bias.

Collecting Responses

To collate usage data from the participants into how well they perceived the usefulness of each, a *System Usability Scale* (SUS, Brooke 1996) based set of questions was created. These are 10 questions on usability measured on a 5-point Likert scale with defined levels of success and reliability for the singular overall value that is afterwards calculated. This was decided as suitable for the experiment due to its successful use in similar past experiments and, particularly, over other available analysis methods due to the independence of results from sample size; Lewis and Sauro (2009) recommends a sample size of just 12 participants for a good level of reliable results. Bangor, Kortum, and Miller (2008) performed a study

over 2324 different SUS cases to determine the reliability of results. They attained a Cronbach's Alpha of .91, against the target lower boundary for reliability of .7, to establish that SUS gives extremely reliable results for what is a relatively basic data collection method.

An identical set of SUS-based questions were then given to users after usage of each of the two applications. These, like the previous survey, were given to users via Google Forms to avoid any potential differences in feedback from using alternate mediums that could cause issues in directly comparing the results (full question set in Appendix D.3).

To perform timing of these tasks a screen recorder, *AZ Screen Recorder*[1], was utilised whilst participants were completing the tasks and the videos analysed afterwards to determine the length of time spent performing the banking tasks. This approach was used to avoid intrusively observing participants to manually time during tests, as this could have disrupted the way they would otherwise interact with a new system. Lloyds has used Android security features[2] to block all screenshots and screen recordings within the app, meaning a cumulative time for completing all tasks had to be used instead of individual task times by using app entry and exit times.

5.1.5 Price Comparison

After completing the two sets of banking use case instructions, users were asked to re-log back into PSDBank to experiment with the *offers* page and its capabilities. Specifically, they were asked to find and get information on one of the offers for price comparison to ensure they had experienced the navigation layout and could thus give feedback on usability and usefulness of the price comparison integration.

Collecting Responses

Responses were then gathered via a final page in the Google Form (Appendix D.3) that recorded whether participants were interesting in installing a multi-banking app and one with price comparison functionality, as they had when filling out the original survey. They were also given the opportunity to offer any points where they felt PSDBank had advantages and disadvantages compared to Lloyds, as well as any general comments or requests for future functionality.

5.1.6 Consent Form

Due to the nature of the experiment in collecting user data from the participants, a consent form was conceived to be read through and signed by the participants before the test began.

[1] https://play.google.com/store/apps/details?id=com.hecorat.screenrecorder.free

[2] Secure Flag- https://developer.android.com/reference/android/view/WindowManager.LayoutParams.html

As users were not performing actions on any of their own money or personal accounts, this was a simple form giving a brief summary of what they would be asked to do and maintaining their anonymity in the subsequent analysis and release of all collected data. The consent form given to participants can be seen in Appendix D.1.

5.2 Results

The experiment was completed by 10 participants, all of whom had previously completed the survey as part of the initial user study section of the project. Although this falls slightly short of the 12 recommended by Lewis and Sauro (2009) for a reliable SUS-based data set, this was limited by only contacting those who had completed the earlier survey and chosen to leave their contact details for continued participation in the research. Only 10 of these were available within the test dates, but this should still give an acceptably reliable data set for analysis.

5.2.1 Demographics

All of the 10 participants were within the 18-24 age group and fell on the innovative end of the IDT scale, with 4 *innovators*, 4 *early adopters* and 2 adjudged to be part of the *early majority*. This proved ideal for the experiment to find evidence for the attraction of the created system for these innovative participants, as they fall into the targeted audience of the initial system on release.

5.2.2 Usability Results

The 10 SUS questions are reduced down to a single usability score for each of the two systems per person, giving a gauge of how they compare. This is done by standardising each metric to a score between 0 and 4, subtracting one from the odd numbered 'positive' questions and doing 5 minus the given rating for the even numbers 'negative' worded questions. These ten are then summed and multiplied by 2.5 to give an overall score out of 100 (Brooke 1996). This process was applied to the collected raw data (Appendix D.4) to gather the results seen in Table 5.1. The screen recordings were successfully used to extract the total banking task times for each application, also seen in the below data.

Understanding the Results

The SUS results are, importantly, not on a percentile scale for comparison but place the system being analysed onto a structure of usability. The average score of system usability is therefore not 50, but is around 68 (Bangor, Kortum, and Miller 2008), with *good* systems being those attaining over 73 and *excellent* at 85 (Figure 5.1). Whilst both applications

Table 5.1: SUS usability score and task completion time in seconds for the two systems

Participant	PSD SUS	Lloyds SUS	PSD Time	Lloyds Time
1	70	87.5	291.00	118.00
2	65	92.5	156.00	160.00
3	72.5	45	82.00	83.00
4	80	72.5	179.00	128.00
5	67.5	97.5	260.00	237.00
6	77.5	47.5	183.00	190.00
7	50	72.5	247.00	245.00
8	37.5	77.5	215.00	181.00
9	80	75	222.00	190.00
10	90	85	216.00	171.00
Mean	69	75.25	205.10	170.30
Std Dev	15.42	17.46	59.05	50.74

have managed to get above the average score at 69 and 75.25 for PSDBank and Lloyds respectively, Lloyds has a noticeable advantage by being placed up into the *good* results range.

Lloyds also appears to have a large time advantage compared to the new application, with participants completing the Lloyds tasks and questions on average 35 seconds faster than the PSDBank equivalents. Due to the aforementioned Lloyds security-focused screen blocking, this unfortunately cannot be split into further subgroups for time taken per individual task to see where the most time was lost, but it can be reasonably suggested that PSDBank was to some extent less efficient to use.

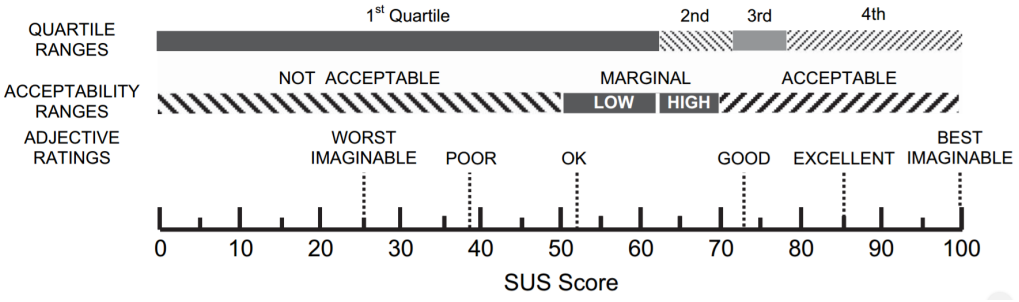

Figure 5.1: Analysis of SUS scores (Bangor, Kortum, and Miller 2008)

Success Relative to Hypotheses

To evaluate the evidence given towards the experiment hypotheses EH1 and EH2, *Analysis of Variance* (ANOVA, Fisher 1925) tests were carried out on the SUS usability scores and time taken to check for significant differences between the two systems on each of these metrics.

Looking at the SUS results and calculating the between-subjects ANOVA statistical significance results gives a p value of **0.442** ($F_9 = 0.646$, $p > 0.05$). With the p needing to be below 0.05 to constitute strong evidence to reject the null hypothesis (Rice 1989), this data gives support to EH1 hypothesising that the two results would be the same.

For timings, the significant different between the means p was only **0.067** ($F_9 = 4.321$, $p > 0.05$). This is close to the 0.05 boundary and, being below 0.1, does give weak evidence supporting the rejection of EH2. This hypothesised that the time taken would be the same for each system, but with the 35 second difference in means it is unsurprising to see some level of statistical distinguishability.

Excluding Participants

However, though those results show some success, potentially stronger correlations could be extracted to support the hypotheses when excluding the responses of the two participants who said that they had used the Lloyds app previously. Mapping the results onto graphs (Figure 5.2, Figure 5.3) shows that participants 1 and 2, those who had used Lloyds before, gave higher usability ratings and took less time using the Lloyds application. Participant 1 in particular shows a strong outlier in the time taken results set that could be ignored for the overall reliability of results. Removing this predictable skewing towards Lloyds for expert users by excluding these two results sets could therefore provide a clearer insight into the opinions of only those seeing the two systems for the first time.

Once the two participant's responses were removed, the results for both usability and time taken become much closer between the two systems, as seen in Table 5.2. The removal drops Lloyds down from the 'good' range of the SUS chart into average range with PSDBank, whilst the average time taken dropped from 34.8 seconds more for PSDBank to 22.37 seconds, in large part thanks to removing participant 1's outlying result.

After removing the two sets of user data, the remaining field of 8 is admittedly falling further short of the ideal number of participants for a reliable SUS-based experiment. However, this reduced data set gives much stronger statistical similarity evidence supporting the usability hypothesis EH1. The p value rose from **0.442** to **0.819** ($F_7 = 0.057$, $p > 0.05$), further showing a lack of significant differences in the mean of the usability results.

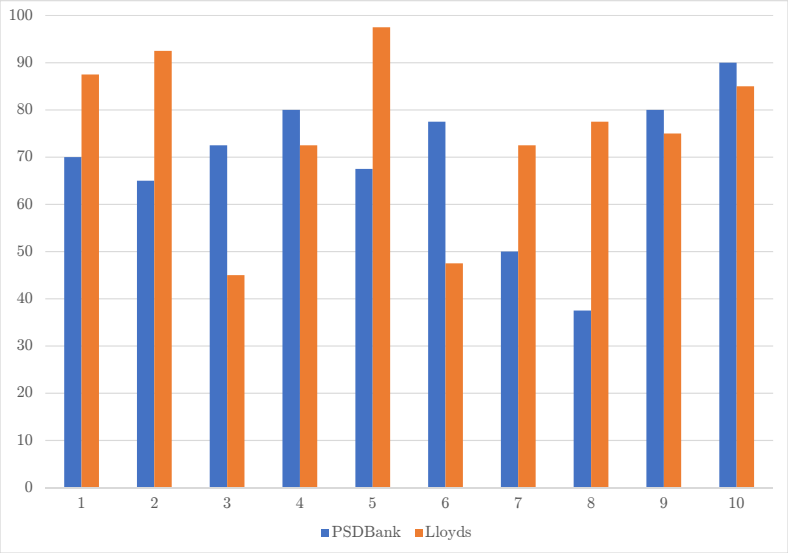

Figure 5.2: Graphic showing each participant's SUS scores for both PSDBank and Lloyds

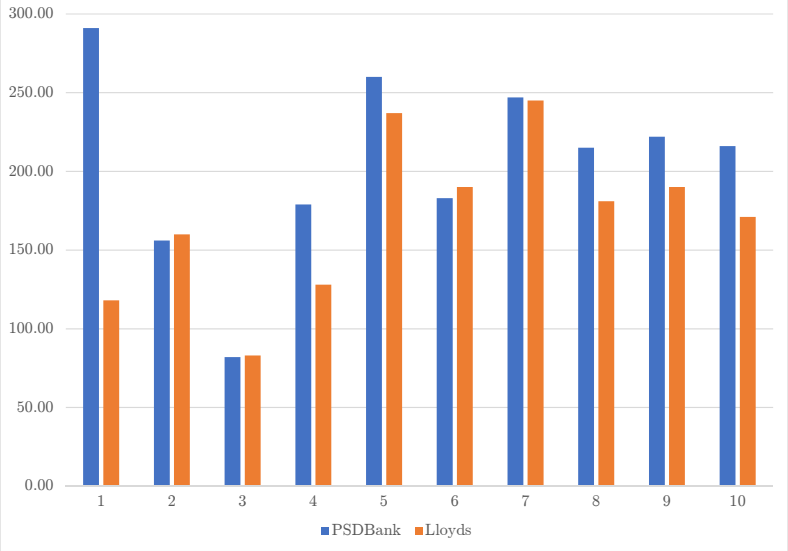

Figure 5.3: Graphic showing each participant's time taken to complete tasks for both PSDBank and Lloyds

However, removing these two does increase the statistical likelihood of the times being different, with the p value dropping to **0.024** ($F_7 = 8.29$, $p < 0.05$). This falls below the 0.05 threshold and thereby EH2 must be rejected, with strong evidence now in place against its hypothesis that the two systems' usage time would be the same.

Table 5.2: Comparison between the mean averages of primary results with and without the previous Lloyds users

	PSD SUS	Lloyds SUS	PSD Time	Lloyds Time
Full Results Set	69	75.25	205.10	170.30
Without Prior Users	69.38	71.56	200.50	178.13

These results therefore give strong supporting evidence towards EH1, whilst EH2 is rejected.

5.2.3 User Adoption

To find supporting evidence for the experimental hypotheses EH3 and EH4 that participants in the experiment would be equally supportive of installing the application as they had been of intending to use in the initial survey, 'would you install' questions were included within the test. Table 5.3 lists each participant's recorded innovation status, original survey values given for intending to adopt a multi-bank system and one with price comparison integration, and the equivalent new values from this test for their willingness to install each type.

Table 5.3: Original survey results and respective new values for each experiment participant. Innovator Status 1 = Innovator, 2 = Early Adopter, 3 = Early Majority

Participant	Status	Survey Multi-Bank	New Multi-Bank	Survey PC	New PC
1	2	6	7	6	7
2	1	3	5	2	5
3	1	7	7	6	5
4	2	6	5	6	6
5	1	7	7	4	6
6	2	6	6	6	7
7	3	5	5	5	3
8	3	5	5	6	2
9	1	6	6	5	4
10	2	6	6	7	6
	Mean	5.7	5.9	5.3	5.1
	Std Dev	1.16	0.88	1.42	1.66

These results are very similar to the original 'intention to adopt' figures given in the survey in most cases, resulting in a slight average increase for willingness to install a multi-banking

app and a slight drop in those wanting to adopt a price-comparison integrated system. This slight drop could be due to the mocked out data and relatively undeveloped offers part of the application, with users potentially more likely to find worth in the price comparison functionality when the offers relate directly to their accounts and saving them money.

SITAM Implications

To statistically evaluate these findings, the *Wilcoxon Signed-Rank* test (Wilcoxon 1945) was utilised as a non-parametric hypothesis test, as this stands as ideal for comparing related samples. This led to Wilcoxon p values of **0.414** for multi-bank (Z = -0.816, $p > 0.05$) and **0.809** (Z = -0.214, $p > 0.05$) for price comparison integration, providing strong evidence for the hypotheses EH3 and EH4 respectively.

Getting p values greater than 0.05, and thus failing to reject the hypotheses, implies that the SITAM-driven conceptualisation and design approach has led to the creation of a system that meets the desires of the innovators it was aimed at. This provides some evidence supporting the use of the SITAM to identify primary features and designs, as the participants appear to be satisfied by the created product enough to give high intention to adopt figures.

As the more innovative original responders to the survey much preferred having no notifications for price comparison sourced offers, and this experiment has resulted in significantly higher adoption rates for multi-banking without price comparison integration, it can be conjectured that these features should be as unobtrusive as possible. The integration has however had enough positive comments and ratings throughout the process to indicate its usage should continue, to offer users money saving deals and remain the primary revenue-producing feature of the system via referral fees.

5.2.4 Other Comments

In addition to the set questions, some optional open-ended ones were available to fill in by participants at the end of the study. These were structured into asking the main positives, negatives and things to add/improve for PSDBank in relation to Lloyd's offering.

Positives

The overwhelming response for this question was the inclusion of multiple accounts, with 9/10 responses including praise of this feature. Five of these also mentioned the inclusion of the offers page and general price comparison integration as a main positive for the new system when comparing against the Lloyds app.

The only other aspects mentioned were the "consistent interface" being more intuitive, and the visualisation of spending habits via the use of various graphics.

Negatives

Responses were more varied when asked for the negatives of the new system, but revolved mostly around the user interface and difficulties intuitively working out how some parts worked. For example, one participant commented that it was "not immediately obvious you can scroll" the interfaces, as the tiles perfectly fitted on the screen without the next poking out. Though a valid criticism for this case on the test phone used, the tile sizes were chosen as standard and different phone screen sizes would therefore already fulfil this recommendation.

An interesting comment levelled at the interface was that it "seems a bit more generalised" than the Lloyds app. Though this feels somewhat inevitable to be able to encompass many different banking institutions into one, perhaps further thought could be given to establishing more of an identity for the app.

Requests for Future

The requests section had less feedback, but a few useful suggestions stood out as things to think about in future iterations. One was to include a help/tutorial for application use on first opening of the app, which could work well to negate some of the navigational issues encountered by participants and described in the negatives section.

Two reviewers indicated that they would like to either enter the application in the accounts rather than splash screen or that the splash should include a static initial tile displaying an accounts overview and balance. Interestingly, the comment requesting the first screen be the accounts page, as it is in the laggard-aimed design, was an 'early majority' status member and hence the least innovative of participants in the experiment. This therefore stands as an important piece of functionality that could be introduced as adoption heads towards the majority status groups.

5.3 Summary

The experiment was successfully designed and performed on a subset of participants from the initial user survey, helping to connect their original innovative statuses and feedback to that given once having seen and used the new application. Comparing with Lloyds, deemed to be the best current UK banking app earlier in the research, has worked well to provide an optimal benchmark to strive for in order to take custom from the banks on release.

Though the new 'PSDBank' did not quite reach the SUS usability rating received by Lloyds, the usability hypothesis was not rejected. Working on the assumption that as the best banking app no other would currently rank as more usable than Lloyds, it can therefore be reasonably suggested that the new system fulfils its primary aim of being *at least as* usable as current mobile banking options. Whilst it remains a future goal to get system usability above the 'OK' SUS zone (Figure 5.1), it essentially only needs to be as good as bank apps to get convert customers rather than needing to be excellent to use in its own right. With this in mind, the huge added benefit of being the only multi-banking application available should be enough of an incentive for the system to overcome the trade-off and be a success upon release, even without further development on the usability of the product.

There was however a significant difference in the time taken by participants to complete tasks on each system, with the related hypothesis rejected. This is a failure of the created application against its aims, but further experimentation would be needed to see if such differences endured when users become experts at using the applications, as opposed to being first time users.

Responses from the experiment also suggested the successful use of the SITAM in development, as within the dissertation a new system was built to the requirements created from the SITAM results that ended up being accepted as suitable by members of the primary target market for this initial version.

Finally, the conclusions section will bring together all aspects of the project to assess the overall level of success against the initial aims. It will also offer useful advice for future developments incorporating the SITAM or looking to exploit the opportunities resulting from PSD2.

Chapter 6

Conclusions and Future Developments

In concluding the project, there will be an insight into the success of the created system relative to the initial aims as laid out in the introduction (Section 1.1.2). Also provided are a critical review of the limitations of PSDBank in its current form, plus guidelines and suggested areas of future research for PSD2 related developments.

In addition to the initial project aims, the conceptualisation and construction of the *Social Intention Technology Acceptance Model* (SITAM) became pivotal to the project. This became the core factor behind much of the following investigative work, and as such a full evaluation of the success of this and recommended guidelines for future developments incorporating the SITAM are provided.

6.1 Payment Services Directive II

The new European legislation PSD2, in particular the 'access to account' XS2A articles (see Section 1.1.1), stand as uniquely placed to shake up the monopoly large institutions have on certain financial markets. Whilst FinTech firms have been growing in size and recognition in recent years (Section 2.1.2), the passing into law of XS2A will truly open the international payments market for these smaller firms to potentially make an impact - hopefully improving the end experience for users in the process.

6.1.1 PSDBank Limitations

Focusing on a singular extension of multi-account banking applications, price comparison integration, was both a strength and a weakness of the research. This path failed to investigate which type of multi-bank application would be best adopted and so have the

most development potential, a subject which a wider approach may have been able to contribute valuable conclusions to. However, a breadth rather than depth based research model within the confines of an undergraduate dissertation environment would have failed to model adoption on working prototype systems and so get the level of adoption evidence collected within this work.

Ultimately, the primary limitation of the project was always going to be the inability to create any working proof of concept, with the research and publication a number of months before the planned public implementation of PSD2. This research stands as an investigation into the potential adoption and market infiltration new third party mobile finance apps could hope to achieve given access to direct data from account providers, and as such has hopefully achieved in its aim to provide guidelines for developers looking to work in the space in the years ahead. However, initial assumptions that some level of security requirements or API information for PSD2 would be released by the project development period proved to be false. This altered the direction of the implementation stage away from its planned focus on the security aspects of mobile banking (Section 2.2.1) and more towards the theoretical maximising of adoption based on the concepts of innovation encompassed by the newly devised SITAM.

6.1.2 Guidelines

For developers looking to enter the third-party financial provider market, especially in ventures exploiting actions enabled by PSD2, there are several main points to consider. The following loose guidelines are composed from the findings of the literature review and the problems encountered within this work whilst developing the PSDBank application. These are split into three factors of consideration: *ethics, security* and *the future*.

Ethics

Any attempt to collect a substantial list of ethical considerations for personal finance systems, especially when looking to monetise the data, would result in a myriad pyramid of different viewpoints and rules. However, developers can do their best to avoid controversy by ensuring the rights of users are enshrined in ethical boundaries at the start of the design process, enveloping them into each following stage of creation.

In this research, the theory of system monetisation was in employing user data with price comparison services to offer deals recommendations; saving the customers money whilst collecting referral fees, much as price comparison sites do. User feedback on this functionality was mixed, but comments suggested general approval so long as the suggestions were truly in the user's best interest and that they could choose to turn off all external exportation of data. With this in mind, it can be suggested that the key ethical point is ensuring user understanding of exactly how and why their data will be used, whilst providing the

option for users to switch this off if they so choose.

Even if this results in lower revenues, the ethical boundaries set out at the start of projects must never be infringed upon - if one application in the space goes rogue in disrespecting their users' personal information, the industry as a whole could close up under deep regulation and invariably find it hard to re-establish credibility with consumers.

Security

Also relating to the acts of receiving and utilising sensitive personal information are the surrounding security connotations. As researched in Section 2.2.1, and augmented by the strong relation of the *perceived credibility* construct to a user's intention to use a system, the public's trust in the system must be sufficiently high to achieve desired levels of adoption. When considering the many hacking, phishing and malware related security risks present for mobile applications, the need for tight security becomes paramount.

With many banking institutions intimidated by the market shift that could result from PSD2, any well-publicised breaches in third-party provider systems could be the catalyst banks need to argue the suspension of XS2A rules on security grounds. They could at least look to use their considerable influence to add in extra steps and requirements for the TPPs; innocent on the surface, but it could be enough to bury these systems in an unusable multi-factor authentication nightmare.

Therefore, much like with the issue of data-mining ethics, the reputation and feasibility of both individual apps and the TPP market as a whole could depend on the proper and thorough meeting of the PSD2 security requirements. Whilst security may be a tempting area for developers to cut corners to get systems to the market faster, irreparable reputational damage could be the repercussion.

The Future

Finally, anyone looking to enter the market after the release of PSD2 should keep in mind that whilst this is arguably the most exciting opportunity to gain market for some time, the structure of the payments industry as a whole could alter in the coming years. The recent emergence of virtual cryptocurrencies threatens to take overtake usual currency transfers via the efficiency of miniscule transaction and architecture scalability resulting from efficient blockchain use (Barber et al. 2012, Section 2.1.2). The recent public support of blockchain-based transactions by large establishments including Goldman-Sachs (2016) indicates that developers should look to adopt such technology into their payment systems as soon as viably possible; without this it may be impossible to survive on the front line of the technological payments battle.

6.1.3 Areas of Future Research

Due to the date of publication of this research being less than a year before the planned release date for PSD2, there remains relatively little time to conduct a similar preliminary user adoption study. However, this does mean that by the time of future research, the exact details of the legislation should be in public knowledge, including the security requirements and API templates, meaning future work could create more realistic implementations that could actually be plugged into banks as and when they complied with the directive to get real working data in the application.

This leads on to the suggestion that real-world continuous usage of the app in place of standard banking applications should be the aim for future research. This is the only way to gauge accurate user adoption figures and so properly judge the success of the PSDBank design in achieving a suitable level of usability. The basic act of implementing the security requirements of PSD2, when known, could affect the way users are able to interact with the current designs and this would require further study. Meanwhile, the financial viability of the system would need to be tested by gathering real-world data into the number of offers actually taken up on by users of the application, with potential for further studies into the data science behind the analysis of such deals.

Additional to the more niche area of price-comparison integrated multi-bank applications, there is a multitude of other potential applications made possible by the opening up of account data that researchers can look to develop and test using influences from this dissertation. One only has to look at the variety of ways personal online browsing data has been used to know the potentially huge value of access to personal financial information.

6.2 Evaluating SITAM-Based Development

From the reading of previous research and analysis of results attained through the new *Social Intention Technology Acceptance Model*, an ideal set of user guidelines for developers looking to utilise SITAM-based development can be constructed. In addition to listing this suggested process and its projected positive and negative attributes, a critical evaluation of the study's limitations will be given with suggestions of ways to further the research. Execution of some of these should help to construct a more reliable conclusion of the SITAM's success, especially amid its projected area of long-term product development.

6.2.1 Guidelines

Suggested guidelines for the project based on the experiences in this research that can advise the course taken by future developers taking on any aspects of the new model.

Suggested Process

1. Perform initial user survey
    - Estimate innovative status group of survey participants
    - Gain opinions on potential features and designs, harvest a suitable number of responses for each status group
2. Develop products aimed at each status group
    - Analyse survey data to gain 5 distinct product requirement sets
    - Construct and iterate over prototypes for each with feedback from respective group members
3. Use innovator group design as initial product, cataloguing others for later implementation
    - Need to attract innovators in order to later diffuse into the other status groups
4. Project product roadmap
    - Forecast potential final market share, taking competition into account
    - Using projected percentiles from Innovation Diffusion Theory, predict the target innovation status group at different adoption rates
5. Ongoing development aimed at current status group
    - Focus on wants and needs of the innovation group at current roadmap stage
    - Begin development of alterations required to meet ideal product for following group when getting close to target adoption of current group
    - Release new version at opportune time, keeping backwards compatibility of features designed for earlier adoption groups when large alterations made
6. Continue focus and release cycle until reaching release for the laggard category
    - This stage reached only in successful products or where original predicted possible adoption level too low

Stage 3 may need to be re-calculated at various times throughout the process to reflect the latest potential final adoption figures based on product success and competition.

6.2.2 Advantages

One of the main advantage of using SITAM-based development is gaining a clear project roadmap even before initial release, enabling the preparing of code to encompass the known future implementation of features. This should produce clean architectures and easily scalable and maintainable code for the organisations that choose to use it, saving time in future re-writes to add unexpected new features after mid-life user studies.

However, the main hypothetical advantage is that abiding by the IDT should be the key to ensure rapid initial expansion and continuous growth, against usual user research that fails to distinguish the innovative nature of participants and rank their opinions accordingly. Even if systems have vastly different designs for innovators and laggards and so fail to appeal at all to the later status groups initially, the set of system designs should propagate eventual expansion into those user groups as long as the most influential users are targeted first.

6.2.3 Disadvantages

As for disadvantages of the SITAM-driven approach, there is a large initial overhead to create and carry out the user studies required to identify innovative dispositions in participants before analysing this to create 5 fully separate designs to cater for each group's wants. There is also the issue that initial projections of market adoption may need ongoing revisions to stay relevant with the latest potential user base and competition in the market, possibly altering development timelines.

The main disadvantage for now is the potentially flawed assumptions underlying much of the model. Adoption-diffusion theories are known to have an implicit pro-adoption bias (Straub 2009), meaning initial predictions could overestimate adoption, whilst the underlying model assumption that developers can move focus to a new user group without losing adoption levels of the previous needs further evaluation.

6.2.4 Limitations in this Study

The biggest limitation of the study in terms of SITAM-based development was certainly only being able to perform the first 3 stages of the advised process. This smaller scaled experiment was primarily down to both time constraints, meaning an ongoing product timeline could not be studied, and that no working consumer product could be released prior to enactment of PSD2. Stage 2 of the guidelines was also restricted, concentrating only on creating innovator and laggard based designs rather than a full repertoire of 5 requirement sets and designs that could have demonstrated a more gradual product evolution compared to the fairly stark differences between those created.

However, the survey and analysis helped to unveil considerably different results on the feature requirements of the innovation groups. The following initial product based on the innovator group design gained suitable levels of usability when compared to Lloyd's mobile banking app, whilst maintaining good levels of intention to adopt from the initial user survey on those participants.

A restriction on the final experiment was certainly a lack of users to take part in the study, with the usage only of those who had previously carried out the survey and chosen to divulge their email resulting in 10 participants being the maximum achievable. There was also a demographic bias towards the innovative end of the innovative scale within the *Innovation Diffusion Theory* groupings, perhaps inevitably due to the university-based setting of the research, that could have negatively affected the data influencing the design choices made.

6.2.5 Areas of Future Research

As with the PSD2 future research suggestions, real-world app usage must be a key aim for any future work using the SITAM model to attain ongoing adoption figures. This would then provide accurate data into how closely adoption followed the projected curve of the innovation diffusion theory graph and whether further efforts are required to accurately map points on the graph to relevant parts of the timeline. Though the model should allow development ahead of time, and limit ongoing user studies, if product timelines go on for some years the initial requirements for the later status groups may be infeasible or ineffective by the time of release.

In terms of gathering findings, future studies should ideally look to sign up participants for the whole course of tests to be able to use them for the initial survey, prototype feedback and the final product usage experiments. Using this approach with a more varied demographic participant set spread over the IDT spectrum would help to give a more reliable and trustworthy set of figures to extrapolate across the whole population of potential users.

An interesting area of future research in addition to testing the effectiveness of the advised process could be to incorporate ideas from *Information Foraging Theory* into the project timeline to help determine the most efficient time to move focus between innovation groups. Foraging Theory, as described by Pirolli and Card (1999), is the act of determining optimal time to spend working within a patch, in this case a status group, based on the rate of gain and the effort required to move on. This nature-influenced theory could potentially optimise the transition between designs during product lifetimes, though would require a good level of previous standard SITAM-based development research to be carried out first for comparison.

6.3 Project Summary

This research explored the opportunities offered by new legislation and identified a unique product opportunity in the market, investigating its potential for full development. In terms of its original objectives (Section 1.1.2), the project has been largely successful, with the only real failing being that the system was unable to implement the security features required by PSD2 due to these not being released by the time of development. Carrying out and evaluating the created system against a popular UK retail banking application helped give evidence that it could slot into the disruptive payments industry subsequent to the new legislation coming into full force.

Meanwhile, the SITAM shows promise for optimising the adoption speed of new innovative products and could prove highly influential should any developers embrace the proposed methodology in a new project and gain favourable results from it. It also appears to be highly suited to products such as those set to appear following PSD2, where initial adoption should prove vital to establish market dominance - due to the user overheads of inputting data and overcoming initial trust boundaries involved with switching to another service, the first multi-banking application to find market popularity could prove hard to displace.

PSD2's attempt at standardising banking practices to make the single market fit for the digital age will mean developments from anywhere in the EU could gain monopolising adoption levels across the Eurozone. With the vast numbers of applications that will be looking to take top spot, perhaps sociologically minded approaches to developing software like the SITAM can be the key to establish market dominance.

6.4 Paper Submissions

Two conference papers are being written based on the findings of the dissertation:

Integration of Innovation Diffusion Theory with technology acceptance modelling to inform system design throughout a project life cycle explores the creation and success of the SITAM methodology and will be submitted for entry to CHI 2018 (see Appendix F.1).

How PSD2 could improve user interactions with personal finance and lead to a FinTech revolution within the mobile banking market looks into the consequences of PSD2 for FinTech firms and for Europe's large financial institutions. This will be submitted to Deutsche Bundesbank's conference 'The Future of Financial Intermediation: Opportunities and Challenges Posed by Regulatory Reforms and New Technologies' to be held in November 2017 (see Appendix F.2).

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Appendix A

Survey Results

A.1 Full Survey

Full original Google Forms document with questions and answer entry points.

Mobile Banking Feedback

Thank you for taking the time to answer questions related to your banking habits and opinions on a new system within the field. The following questions are over two pages and should take approximately 5 minutes to answer.
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*Required

1. **What age range are you in?** *
   Mark only one oval.

   - ◯ 16-18
   - ◯ 19-24
   - ◯ 25-30
   - ◯ 31-40
   - ◯ 41-50
   - ◯ 51-65
   - ◯ 66+

2. **Which statement applies to you the most?** *
   Tick all that apply.

   - ☐ I always have to have the latest new technology as soon as it comes out
   - ☐ I tend to be an early adopter of new technology
   - ☐ I generally wait until others have tried and recommended new technologies before adopting myself
   - ☐ I'm often a bit late to the party and need a lot of recommendations before I pick up new tech
   - ☐ I'm usually the last of my friends to pick up new technology

3. **How many different UK banks (Lloyds, Barclays, etc) do you currently hold accounts or have credit cards with?** *
   Mark only one oval.

0	1	2	3	4	5	
◯	◯	◯	◯	◯	◯	5+

4. **Out of these, how many do you use with online banking?** *
   Mark only one oval.

0	1	2	3	4	5	
◯	◯	◯	◯	◯	◯	5+

5. **Out of these, how many do you use with mobile banking?** *
Mark only one oval.

0	1	2	3	4	5	
◯	◯	◯	◯	◯	◯	5+

6. **Out of these, how many do you use with Android/Apple Pay** *
Mark only one oval.

0	1	2	3	4	5	
◯	◯	◯	◯	◯	◯	5+

7. **Out of the following statements, indicate your agreement or disagreement with each:** *
1=Strongly disagree, 2=Mostly disagree, 3=Somewhat disagree, 4=No opinion/Not relevant, 5=Somewhat agree, 6=Mostly agree 7=Strongly agree
Mark only one oval per row.

	1	2	3	4	5	6	7
I trust the security of online banking to protect my money	◯	◯	◯	◯	◯	◯	◯
I trust the security of mobile banking to protect my money	◯	◯	◯	◯	◯	◯	◯
I would trust a third-party application (not affiliated with my bank) to do mobile banking through	◯	◯	◯	◯	◯	◯	◯

8. **How many times have you used price comparison providers (CompareTheMarket, MoneySupermarket, etc)?** *
Mark only one oval.

- ◯ Never used one
- ◯ Once
- ◯ A few times
- ◯ Regularly used them

9. **If you had used price comparison sites, have you ever used them for comparing financial products? (bank accounts, loans, etc - NOT insurance)** *
Mark only one oval.

- ◯ Yes
- ◯ No

10. **Out of the following statements, indicate your agreement or disagreement with each (if you haven't used the feature, please select 'Not Applicable')** *

1=Strongly disagree, 2=Mostly disagree, 3=Somewhat disagree, 4=No opinion, 5=Somewhat agree, 6=Mostly agree 7=Strongly agree
Mark only one oval per row.

	1	2	3	4	5	6	7	N/A
Mobile Banking applications are easy to use								
Price Comparison sites are easy to use								
I would check price comparison sites before switching bank accounts								
I trust price comparison sites with the personal information I input to get quotes/recommendations								
I would be happy to link my bank accounts to price comparison sites to save time inserting information								

Proposed New Finance Application

PAGE 2/2

11. **This survey is analysing the response for a new system that will be able to integrate all users' accounts from different banks, thanks to new regulations, to allow standard transactions and account management in one place. Out of the following statements, indicate your agreement or disagreement with each** *

1=Strongly disagree, 2=Mostly disagree, 3=Somewhat disagree, 4=No opinion, 5=Somewhat agree, 6=Mostly agree 7=Strongly agree
Mark only one oval per row.

	1	2	3	4	5	6	7
I would be interested in installing and using such an application							
I think using the application would reduce the time required to manage my bank accounts							
I would trust the application less than banking applications							
Security concerns would be my biggest reason for not adopting the application							

12. **Now imagine the new application also analysed account and spending information on your accounts to recommend how to save money via price comparison sites (eg. suggesting switching account provider). Out of the following statements, indicate your agreement or disagreement with each** *

1=Strongly disagree, 2=Mostly disagree, 3=Somewhat disagree, 4=No opinion, 5=Somewhat agree, 6=Mostly agree 7=Strongly agree
Mark only one oval per row.

	1	2	3	4	5	6	7
I would be interested in installing and using such an application							
I would trust the application less than banking applications							
I would trust the application less than price comparison sites							
I think I would trust that recommendations would save me money							

13. **If you were installing the application, which of the following options would you prefer for giving money saving recommendations?** *
Mark only one oval.

- ◯ Occasional 'push' notifications that appear on your smartphone to inform of new recommendations
- ◯ Occasional 'push' notifications that appear on your smartphone but stop for a number of months after enacting one of the recommendations
- ◯ 'Weekly roundup' notification
- ◯ Recommendations only given when going on a special page on the application

14. **What features would you be most likely to adopt the system for? Please indicate your level of desire for each (1 for no interest)** *
1=No interest, 2=Vague interest, 3=Somewhat interested, 4=Strongly desired, 5=Essential
Mark only one oval per row.

	1	2	3	4	5
Cleaner/faster application design to that offered by your current bank(s) offerings	◯	◯	◯	◯	◯
Ability to manage all bank accounts from one place	◯	◯	◯	◯	◯
Spending graphs and usage stats from all cards/accounts	◯	◯	◯	◯	◯
Smart feedback on spending habits, for example to suggest cutting on certain expenses, or predicting if a user can afford large purchases	◯	◯	◯	◯	◯
Price comparison integration for money saving suggestions on your bank accounts	◯	◯	◯	◯	◯
Price comparison integration for money saving suggestions on loans and debt management	◯	◯	◯	◯	◯
Price comparison integration for money saving suggestions on car/home insurance that appear when approaching renewal dates	◯	◯	◯	◯	◯
Being able to see the most common actions of anonymised other users of similar economic output	◯	◯	◯	◯	◯
Link to other user accounts (eg. Facebook) to get more relevant targeted advertisements online, for example seeing skiing holiday deals at the time of year you normally book one	◯	◯	◯	◯	◯

15. **Any other comments on what you'd like to see from the system?**

.....

.....

.....

.....

Thank you! Please press 'submit' below

16. **If you are willing to receive a one-off email in the future inviting you to a short user testing of the application, please insert your email address below (Participants will, at the very least, receive cake related rewards)**

.....

A.2 Results

Full raw results for the survey.

A.2.1 Social Intention

1. What age range are you in?	
16-18	0
19-24	45
25-30	4
31-40	5
41-50	3
51-65	6
66+	1
2. Which statement applies to you the most?	
I always have to have the latest new technology as soon as it comes out	10
I tend to be an early adopter of new technology	20
I generally wait until others have tried and recommended new technologies	23
I'm often a bit late and need a lot of recommendations before I pick up new tech	10
I'm usually the last of my friends to pick up new technology	8
3. How many different UK banks (Lloyds, Barclays, etc) do you currently hold accounts or have credit cards with?	
0	1
1	19
2	33
3	6
4	6
5+	3
4. Out of these, how many do you use with online banking?	
0	3
1	29

2	24
3	6
4	5
5+	1

5. Out of these, how many do you use with mobile banking?	
0	23
1	28
2	11
3	3
4	2
5+	1

6. Out of these, how many do you use with Android/Apple Pay?	
0	47
1	17
2	3
3	0
4	0
5+	0

7. Indicate agreement to the following statements	1	2	3	4	5	6	7
I trust the security of online banking to protect my money	0	1	0	3	16	28	20
I trust the security of mobile banking to protect my money	3	2	4	10	15	22	12
I would trust a third-party application (not affiliated with my bank) to do mobile banking through	19	10	18	10	7	2	2

8. How many times have you used price comparison providers (CompareTheMarket, MoneySupermarket, etc)?	
Never used one	11

Once	10
A few times	34
Regularly used them	13

9. If you had used price comparison sites, have you ever used them for comparing financial products? (bank accounts, loans, etc - NOT insurance)	
Yes	22
No	46

10. Indicate agreement to the following statements	1	2	3	4	5	6	7	NA
Mobile Banking applications are easy to use	1	2	1	7	6	21	18	12
Price Comparison sites are easy to use	0	4	3	10	18	16	9	18
I would check price comparison sites before switching bank accounts	3	11	9	7	17	11	7	3
I trust price comparison sites with the personal information I input to get quotes/recommendations	3	6	13	7	21	11	3	4
I would be happy to link my bank accounts to price comparison sites to save time inserting information	19	18	13	4	6	4	1	3

A.2.2 Potential Adoption

11. For a new system integrating accounts from different banks, indicate agreement with these statements	1	2	3	4	5	6	7
I would be interested in installing and using such an application	5	5	8	8	22	14	6
I think using the application would reduce the time required to manage my bank accounts	5	3	2	9	19	18	12
I would trust the application less than banking applications	0	1	9	8	21	16	13

Security concerns would be my biggest reason for not adopting the application	0	5	6	3	7	20	27
12. For an app analysing user data and integrating with a price comparison site, indicate agreement with these statements	1	2	3	4	5	6	7
I would be interested in installing and using such an application	4	5	14	1	21	12	11
I would trust the application less than banking applications	0	2	8	8	19	20	11
I would trust the application less than price comparison sites	5	12	18	18	6	5	4
I think I would trust that recommendations would save me money	1	3	8	8	33	10	5

A.2.3 Desired Features

Ranking showing how each feature was ranked without and with the weighted opinion rankings based on the social intention rating acquired by given user.

13. If you were installing the application, which of the following options would you prefer for giving money saving recommendations?	
Occasional 'push' notifications that appear on your smartphone to inform of new recommendations	10
Occasional 'push' notifications that appear on your smartphone but stop for a number of months after enacting one of the recommendations	4
'Weekly roundup' notification	16
Recommendations only given when going on a special page on the application	38

14. What features would you be most likely to adopt the system for?	1	2	3	4	5
Cleaner/faster application design to that offered by your current bank(s) offerings	3	13	17	17	14
Ability to manage all bank accounts from one place	7	7	14	25	13
Spending graphs and usage stats from all cards/accounts	5	13	12	26	11

Smart feedback on spending habits, for example to suggest cutting on certain expenses, or predicting if a user can afford large purchases	7	14	15	19	11
Price comparison integration for money saving suggestions on your bank accounts	11	10	18	14	13
Price comparison integration for money saving suggestions on loans and debt management	18	16	15	13	5
Price comparison integration for money saving suggestions on car/home insurance that appear when approaching renewal dates	14	12	18	16	5
Being able to see the most common actions of anonymised other users of similar economic output	20	15	16	10	4
Link to other user accounts (eg. Facebook) to get more relevant targeted advertisements online, for example seeing skiing holiday deals at the time of year you normally book one	44	11	5	4	4

Appendix B

Prototypes

B.1 High-Fidelity Prototypes

B.1.1 Laggard

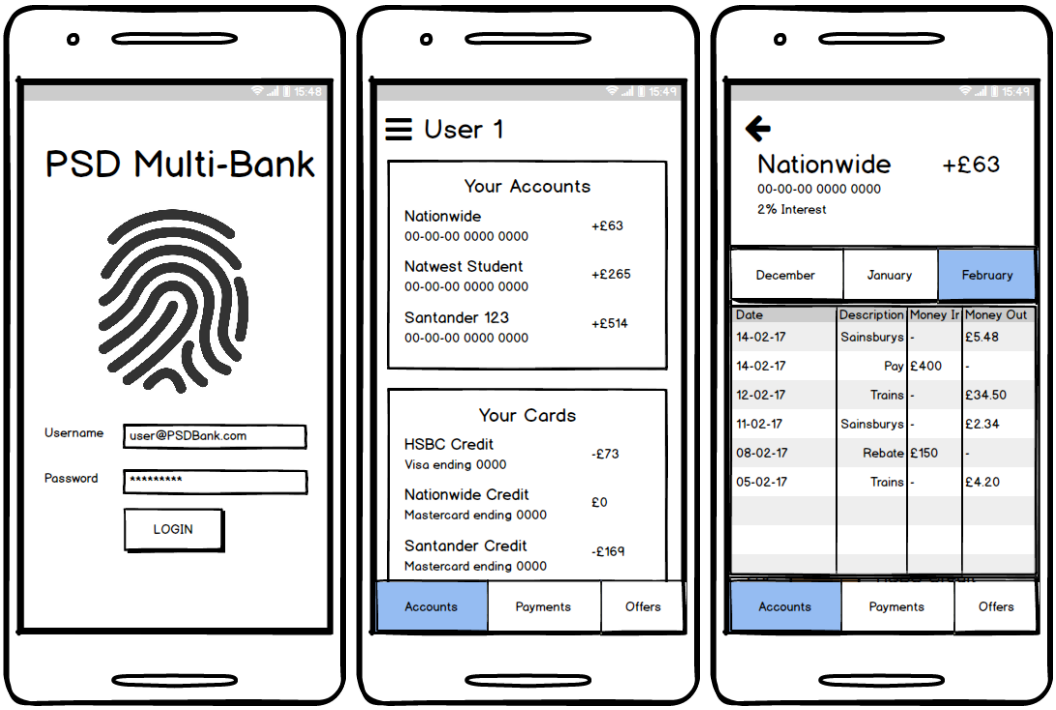

Figure B.1: The proposed login, accounts and options screens

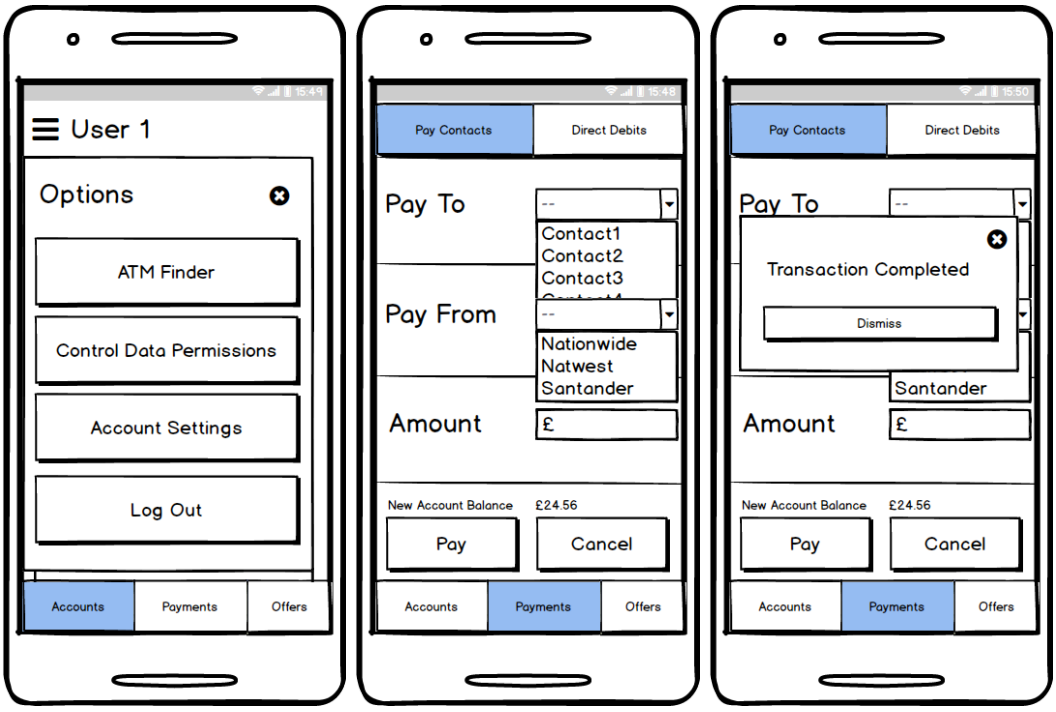

Figure B.2: The proposed options, payments and completed payment screens

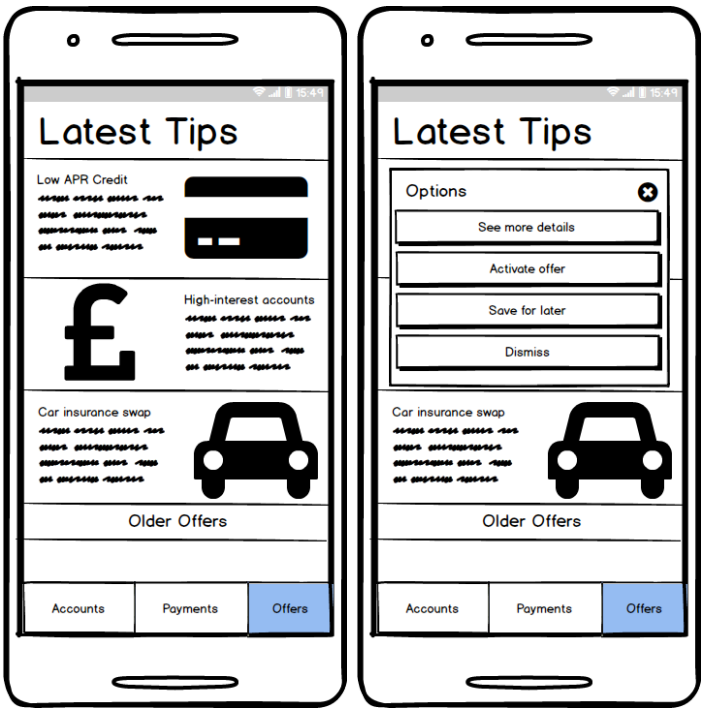

Figure B.3: The proposed offers screen and options

B.1.2 Innovator

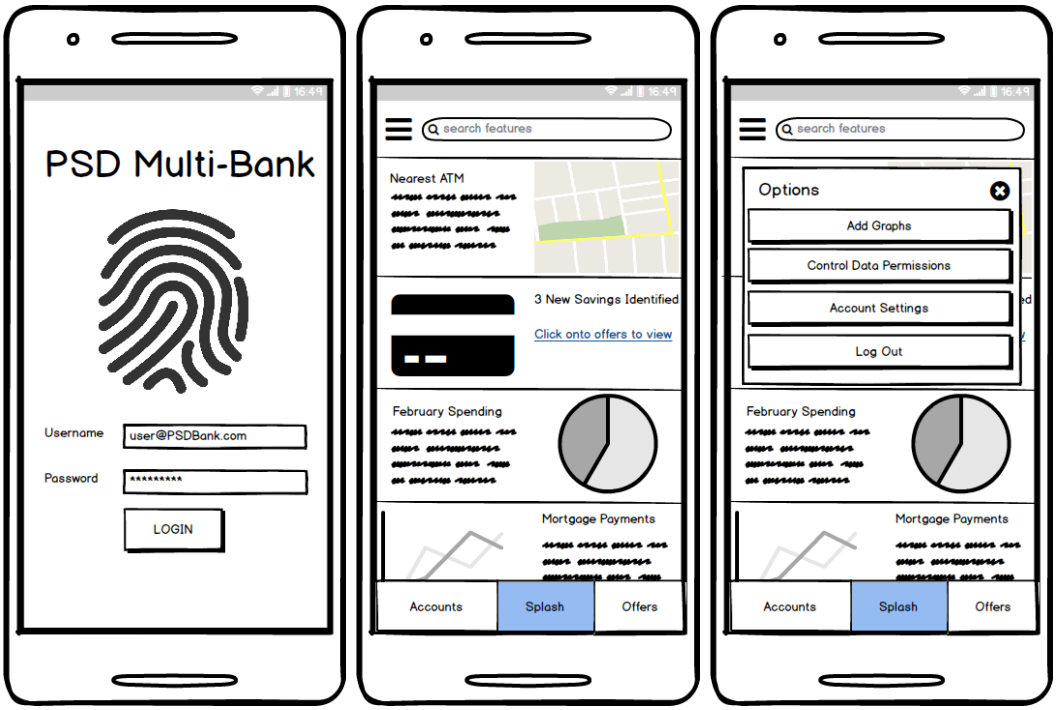

Figure B.4: The proposed login, splash and options screens

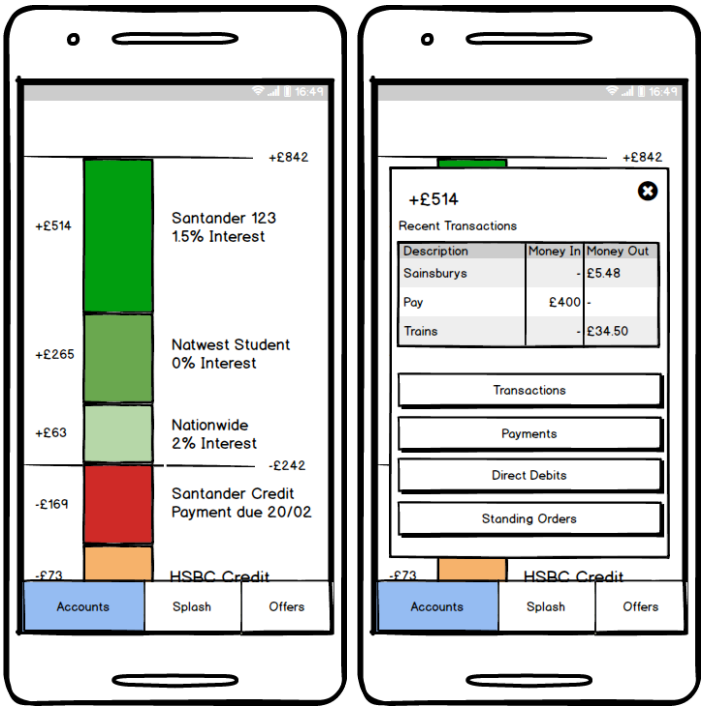

Figure B.5: The proposed accounts screen and options

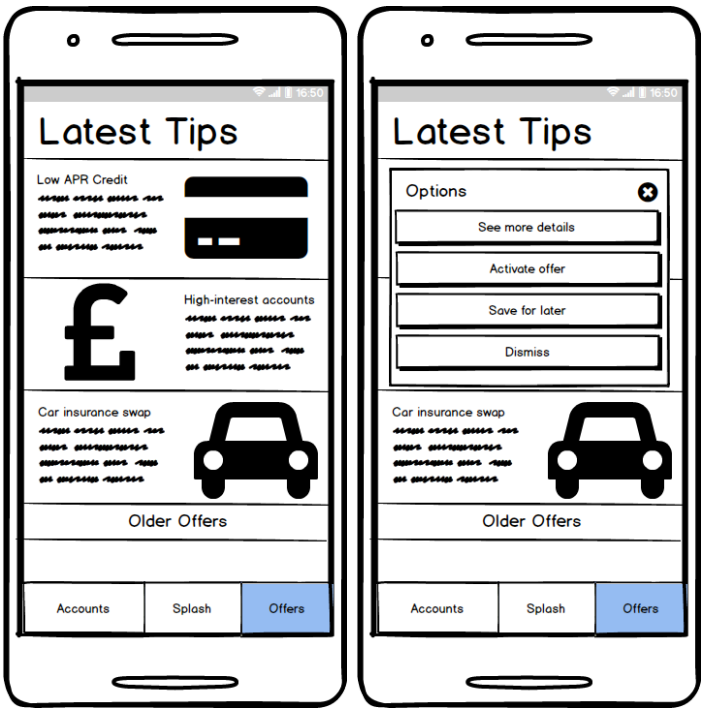

Figure B.6: The proposed offers screen and options

Appendix C

Development

C.1 Android App

Screenshots of use from the new *PSDBank* application.

C.1.1 Application Entry

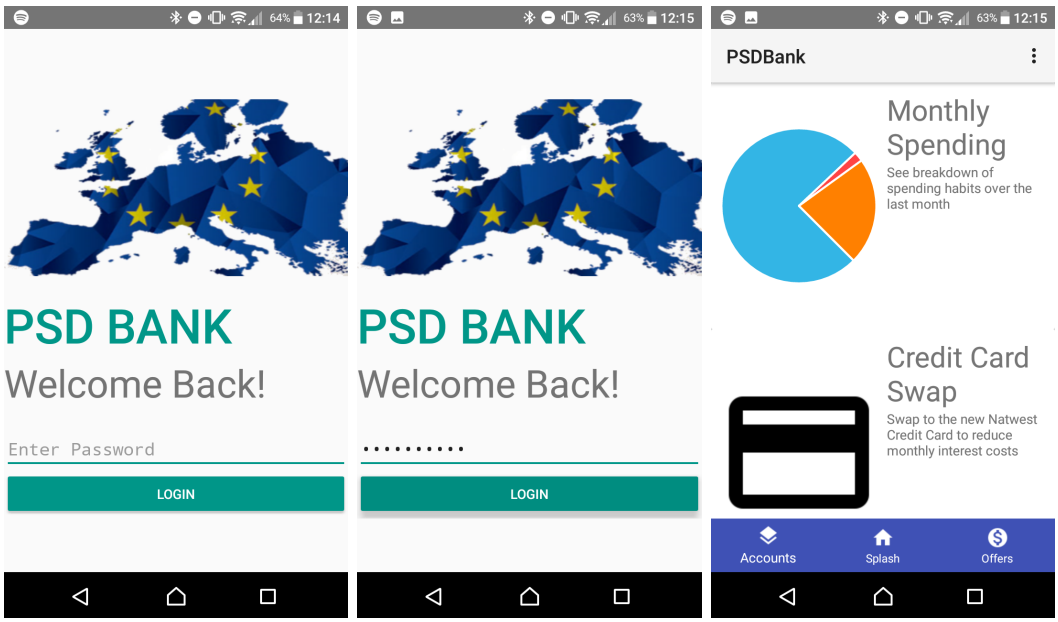

Figure C.1: The created login, splash and options screens

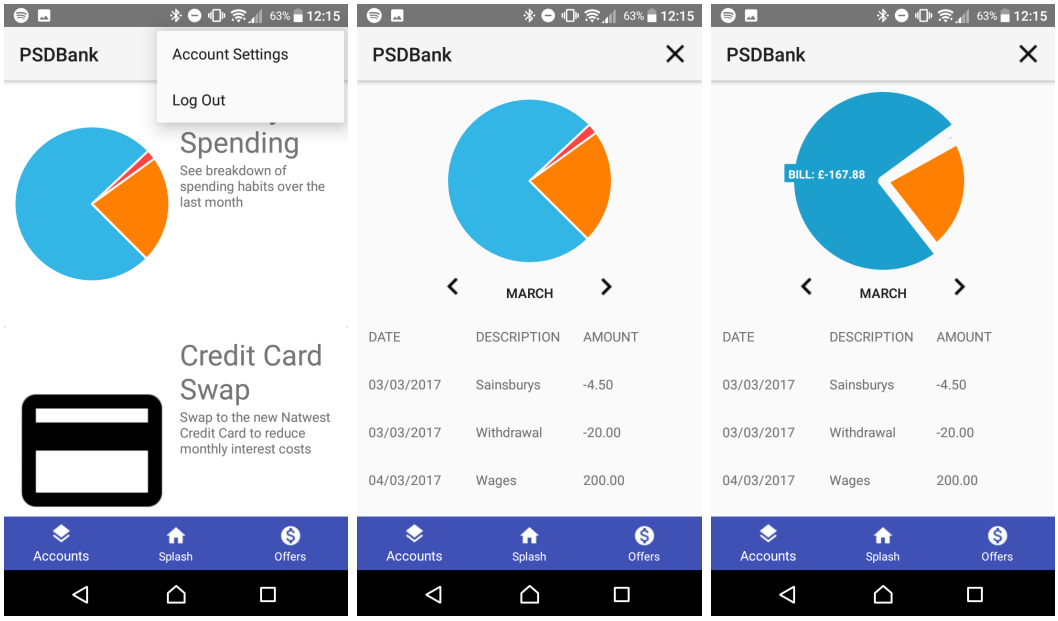

Figure C.2: The created payments split graph from splash

C.1.2 Account Management

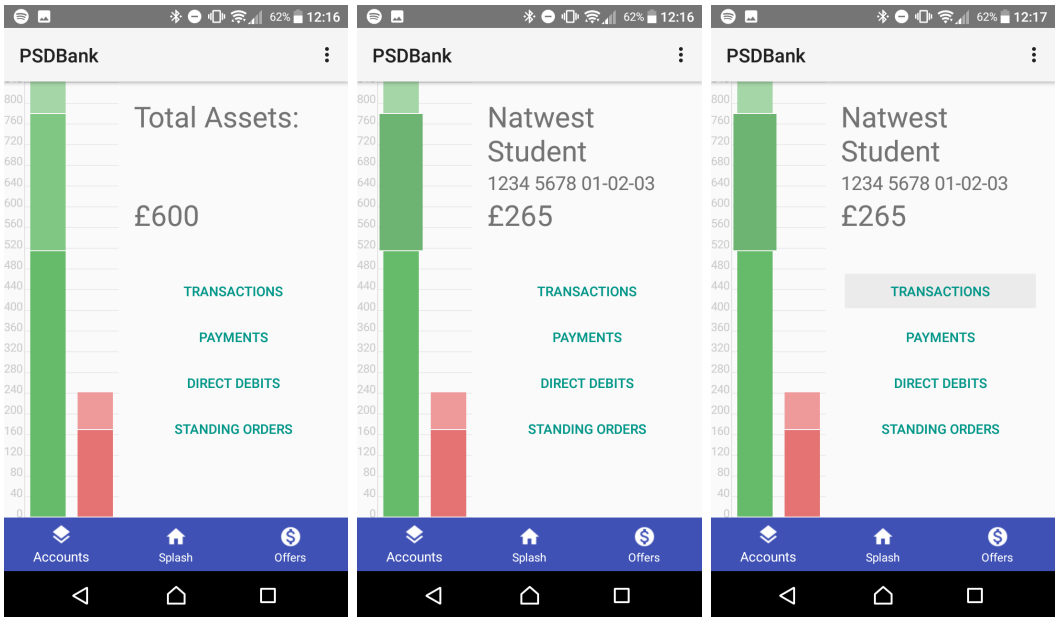

Figure C.3: The created accounts screens

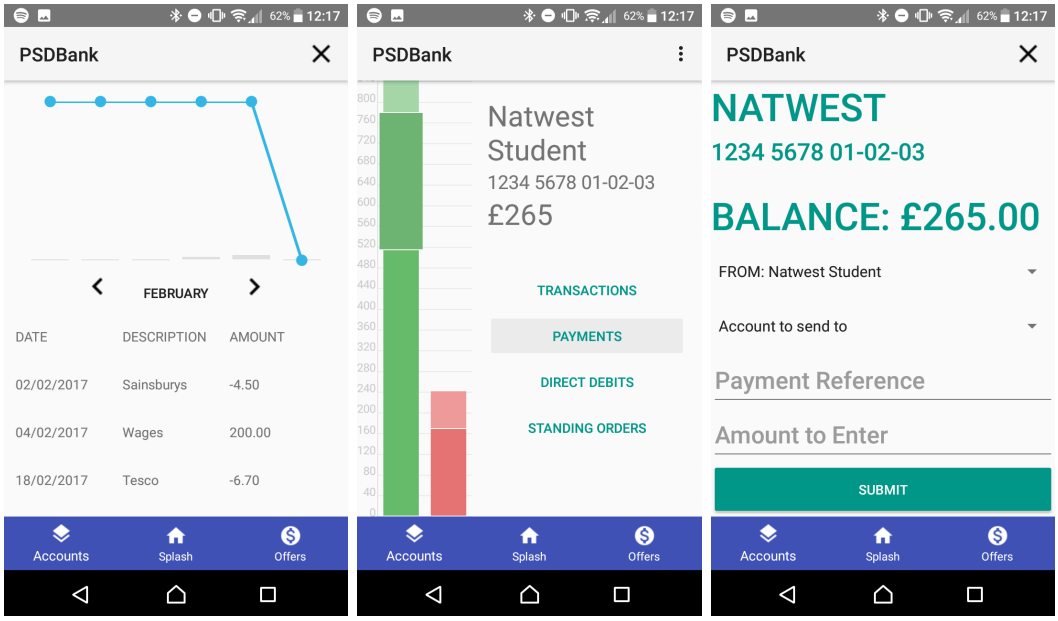

Figure C.4: The created payments system

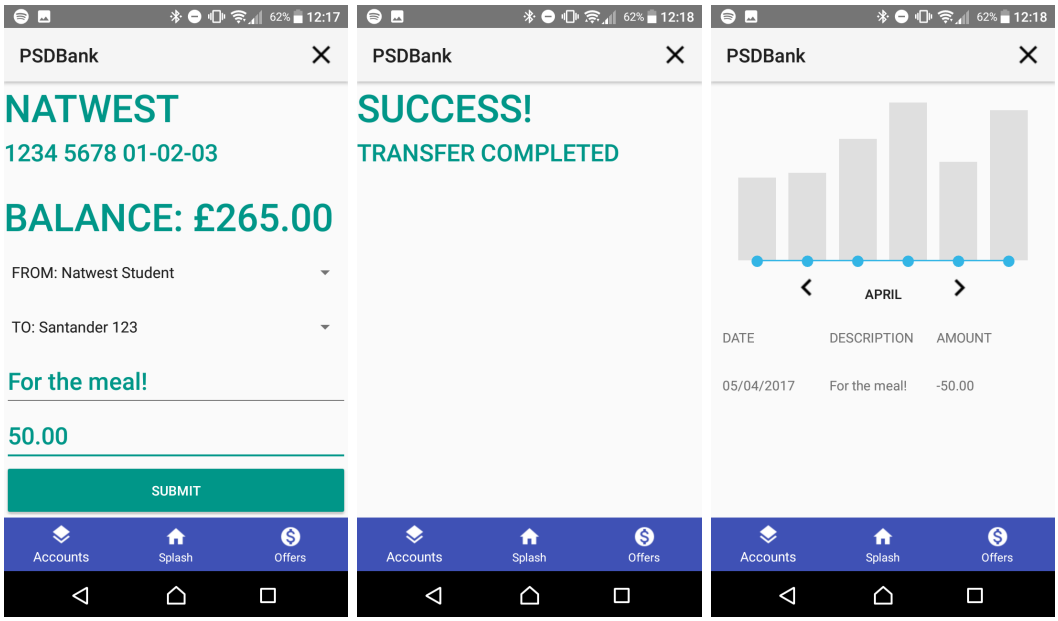

Figure C.5: The created payments system and showing new transaction of successful transfer

C.1.3 Offers

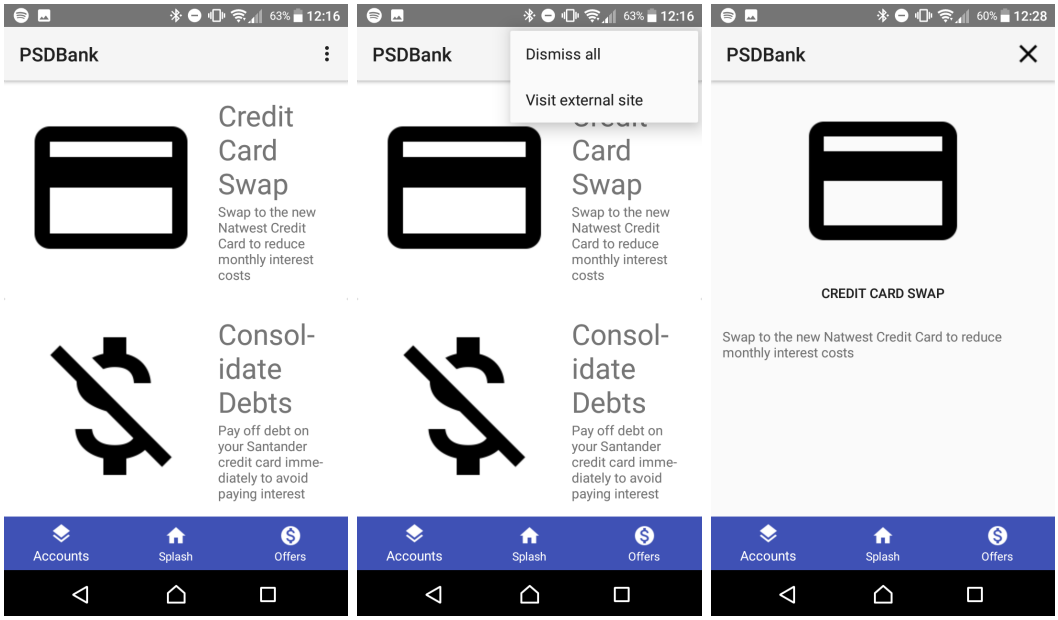

Figure C.6: The created offers view

Appendix D

Experiment

D.1 Consent Form

The consent form given to and signed by participants before beginning the user tasks. This introduces the aim of the project, the type of data collected, the estimated length of time and assures participants of their confidentiality and freedom to drop out at any point.

Experiment Brief and Consent

Overview

The purpose of the experiment is to test the usability and potential adoption of a new banking application.

During the experiment, you shall be asked to use the provided mobile phone to perform three tasks on two different applications. One of these is a real banking application and will require you to perform a monetary transfer using the researcher's account and money. A short question set will be filled in via the provided machine following each of these, before finishing with some open-ended questions should you have any feedback.

Overall this should take around 15-20 minutes though you can stop and leave the experiment at any point.

Confidentiality

All data will be stored securely and anonymously on the Google Forms platform and used only within the means of this research. Names will be removed from all data so that your anonymity will be protected in any research papers and presentations that result from this work.

Consent

Your signature below indicates that you have understood the information about the experiment and consent to your participation. The participation is voluntary and you may refuse to answer certain questions on the questionnaire and withdraw from the study at any time with no penalty. This does not waive your legal rights.

Participant:

Name: ……..

Signed: ……

Researcher:

Name: ……..

Signed: ……

Date: ……..

D.2 Instructions

The instructions list as given to participants. The dotted line represents where the instructions are sliced, with the order of the first two sets swapped for each participant such that half encountered PSDBank first and half Lloyds.

Process Run-Through

Thank-you for participating in this user study. Please follow the steps below in order before entering your feedback using Google Forms on the provided machine.

1. Login to the PSDBank application with the password psdbank123
2. Check the account balance for the Natwest Student account by selecting bars on the accounts graph (each bar represents an account)
3. Take a look at recent transactions for the Natwest Student account
4. Initiate a payment of £1.50 from Natwest Student to Santander 123
5. Re-check recent transactions to ensure the money has been transferred

Please now complete the next page of the form on the computer provided

---

Process Run-Through

Thank-you for participating in this user study. Please follow the steps below in order before entering your feedback using Google Forms on the provided machine.

1. Login to the Lloyds application by filling in the required letters of the memorable information psdbank123 (1:p, 2:s, 3:d, 4:b, 5:a, 6:n, 7:k, 8:1, 9:2, 10:3)
2. Check the account balance for the Lloyds account
3. Take a look at recent transactions for the Lloyds account
4. Initiate a payment of £1.50 from Lloyds to Santander 123
5. Re-check recent transactions to ensure the money has been transferred

Please now complete the next page of the form on the computer provided

---

Process Run-Through

Finally, please complete these steps to gauge your interest in having banking data sent to price comparison sites in order to offer the best money-saving deals.

1. Login to the PSDBank application with the password psdbank123
2. Look at the Offers tab of the application to see price comparison site suggestions for money saving
3. Find and zoom the details of the credit card switch offer

Please now complete the final page of the form on the computer provided

D.3 Feedback Form

The Google Form given to participants to fill out during the experiment.

User Data Collection

Please ensure you have signed the consent form before beginning the experiment.

*Required

1. **Which application have you just used?** *
   Mark only one oval.
   - ◯ Lloyds
   - ◯ PSDBank

Please score the following 10 statements from 1 (Strongly Disagree) to 5 (Strongly Agree) to reflect your usage of the app

2. **I think that I would like to use this system frequently** *
   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

3. **I found the system unnecessarily complex** *
   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

4. **I thought the system was easy to use** *
   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

5. **I think that I would need the support of a technical person to be able to use this system** *
   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

6. **I found the various functions in this system were well integrated** *
   Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

7. **I thought there was too much inconsistency in this system** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. **I would imagine that most people would learn to use this system very quickly** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. **I found the system very cumbersome to use** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

10. **I felt very confident using the system** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

11. **I needed to learn a lot of things before I could get going with this system** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

User Data Collection - App 2

12. **Which application have you just used?** *
Mark only one oval.

- ◯ Lloyds
- ◯ PSDBank

Please score the following 10 statements from 1 (Strongly Disagree) to 5 (Strongly Agree) to reflect your usage of the app

13. **I think that I would like to use this system frequently** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

14. **I found the system unnecessarily complex** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

15. **I thought the system was easy to use** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

16. **I think that I would need the support of a technical person to be able to use this system** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

17. **I found the various functions in this system were well integrated** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

18. **I thought there was too much inconsistency in this system** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

19. **I would imagine that most people would learn to use this system very quickly** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

20. **I found the system very cumbersome to use** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

21. **I felt very confident using the system** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

22. **I needed to learn a lot of things before I could get going with this system** *
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Feedback

Having looked at the offers page and price comparison suggestions within the app, please give some feedback and any improvements you would like made for a future release

23. **I would be interested in installing and using a multi-banking application like PSDBank** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly Disagree	◯	◯	◯	◯	◯	◯	◯	Strongly Agree

24. **I would be interested in installing and using a multi-banking application with added price-comparison integration, like the offers page on PSDBank** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly Disagree	◯	◯	◯	◯	◯	◯	◯	Strongly Agree

25. **What are the main positives for PSDBank in comparison to Lloyds**

26. **What are the main negatives for PSDBank in comparison to Lloyds**

27. **Do you have any feature requests or suggestions for future improvements to PSDBank?**

28. **Have you used the Lloyds app previously?** *
Mark only one oval.

- Yes
- No

Thankyou for taking part in the study!

Please press submit below

D.4 SUS Results

The raw data results from the ten participants for the ten SUS usability scales in the experiment. Questions listed below to match to those in the tables.

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

D.4.1 PSDBank

1	2	3	4	5	6	7	8	9	10
4	3	3	1	4	1	4	2	2	2
2	3	3	1	4	3	5	4	4	1
4	2	4	1	4	2	3	2	4	3
4	2	4	1	4	1	4	2	4	2
4	4	3	1	4	2	4	4	4	1
4	2	4	1	3	2	4	2	4	1
3	4	3	1	3	2	3	4	2	3
3	4	2	2	2	4	3	4	2	3
4	2	4	1	4	2	4	2	4	1
4	2	4	1	5	1	5	1	4	1

D.4.2 Lloyds

1	2	3	4	5	6	7	8	9	10
5	2	4	1	5	1	4	1	4	2
4	1	4	1	4	1	5	1	5	1
3	4	3	1	2	4	2	3	3	3
3	2	3	1	4	2	4	2	4	2
5	1	5	1	5	1	5	2	5	1
3	4	2	1	2	4	4	4	2	1
3	2	3	1	4	1	4	2	3	2
4	2	4	2	4	2	4	2	4	1
4	2	4	1	4	3	4	2	4	2
4	2	4	1	5	2	4	2	5	1

Appendix E

Code Listings

Android code listings for the created *PSDBank* system. These include an example of some Java files containing some logical components of the application, along with some XML layout files.

A small subset of the application has been selected for listing here, as the whole application would extend too far for printing. The rest of the codebase and associated files required for use (images etc) can be found via Moodle.

E.1 Logic Units

A subset of the Java classes comprising the logical segments of the program.

E.1.1 File: ManagerComponent.java

```
package barber.psdbank;

import javax.inject.Singleton;

import barber.psdbank.accounts.AccountFragment;
import barber.psdbank.accounts.IAccountsManager;
import barber.psdbank.graphics.GraphicFragment;
import barber.psdbank.graphics.IGraphicProvider;
import barber.psdbank.offers.IOffersManager;
import barber.psdbank.offers.OffersFragment;
import barber.psdbank.payments.PaymentsFragment;
import barber.psdbank.splash.SplashFragment;
import dagger.Component;

/**
 * Dependency injection manager handles injection of
 * specified classes throughout application
 * This handles singularity of objects
 */
@Singleton
@Component(modules = {ManagerModule.class})
public interface ManagerComponent {

    void inject(MainActivity activity);

    void inject(MyApplication application);

    void inject(SplashFragment splashFragment);

    void inject(LoginFragment loginFragment);

    void inject(AccountFragment accountsFragment);

    void inject(OffersFragment offersFragment);

    void inject(GraphicFragment graphicFragment);

    void inject(PaymentsFragment paymentsFragment);

    IAccountsManager provideAccountsManager();

    IOffersManager provideOffersManager();

    IGraphicProvider provideGraphicProvider();

}
```

E.1.2 File: ManagerModule.java

```
package barber.psdbank;

import java.util.HashMap;

import javax.inject.Singleton;

import barber.psdbank.accounts.AccountsManager;
import barber.psdbank.accounts.IAccountsManager;
import barber.psdbank.accounts.connectors.HSBCConnector;
import
    barber.psdbank.accounts.connectors.IAccountConnector;
import
    barber.psdbank.accounts.connectors.LoginCredentials;
import
    barber.psdbank.accounts.connectors.NationwideConnector;
import
    barber.psdbank.accounts.connectors.NatwestConnector;
import
    barber.psdbank.accounts.connectors.SantanderConnector;
import
    barber.psdbank.accounts.connectors.SantanderCreditConnector;
import barber.psdbank.graphics.ComboChartProvider;
import barber.psdbank.graphics.GraphicProvider;
import barber.psdbank.graphics.IGraphicProvider;
import barber.psdbank.graphics.PieChartProvider;
import barber.psdbank.offers.IOffersManager;
import barber.psdbank.offers.OffersManager;
import dagger.Module;
import dagger.Provides;
```

```
/**
 * Initialisation methods for injection purposes
 */
@Module
public class ManagerModule {

    private AccountsManager accountsManager;

    @Provides @Singleton
    IAccountsManager provideAccountsManager() {
        if(accountsManager != null)
            return accountsManager;
        HashMap<Integer, IAccountConnector>
            accountConnectorHashMap = new HashMap<>();
        accountConnectorHashMap.put(0, new
            SantanderConnector(new LoginCredentials()));
        accountConnectorHashMap.put(1, new
            NatwestConnector(new LoginCredentials()));
        accountConnectorHashMap.put(2, new
            NationwideConnector(new LoginCredentials()));
        accountConnectorHashMap.put(3, new
            HSBCConnector(new LoginCredentials()));
        accountConnectorHashMap.put(4, new
            SantanderCreditConnector(new
            LoginCredentials()));
        accountsManager = new
            AccountsManager(accountConnectorHashMap);
        return accountsManager;
    }

    @Provides @Singleton
    IOffersManager provideOffersManager()
    {
        return new OffersManager();
    }

    @Provides @Singleton
    IGraphicProvider provideGraphicProvider() {
        return new GraphicProvider(new
            PieChartProvider(provideAccountsManager()),
                new
                    ComboChartProvider(provideAccountsManager()));
    }
}
```

E.1.3 File: MainActivity.java

```
package barber.psdbank;

import android.app.Fragment;
import android.app.FragmentManager;
import android.support.v7.app.AppCompatActivity;
import
    android.support.design.widget.BottomNavigationView;
import android.os.Bundle;
import android.support.v7.widget.Toolbar;
import android.view.View;

import barber.psdbank.accounts.Account;
import barber.psdbank.accounts.AccountFragment;
import barber.psdbank.payments.PaymentsFragment;
import barber.psdbank.graphics.GraphicFragment;
import barber.psdbank.graphics.GraphicItem;
import barber.psdbank.offers.OffersFragment;
import barber.psdbank.splash.SplashFragment;

/**
 * Singular main activity of application handles
     initialisation of and communication between
 * the apps fragments (main screens)
 */
public class MainActivity extends AppCompatActivity
        implements SplashFragment.OnOptionsListener,
            GraphicFragment.OnCloseGraphicListener,
        AccountFragment.OnOpenAccountActionListener,
            LoginFragment.OnLoginListener,
        OffersFragment.OnOptionsListener,
            PaymentsFragment.OnCloseListener,
        FragmentManager.OnBackStackChangedListener {

    private FragmentManager fragmentManager;
    private LoginFragment loginFragment;
    private SplashFragment splashFragment;
    private AccountFragment accountsFragment;
    private OffersFragment offersFragment;
    private GraphicFragment graphicFragment;
    private PaymentsFragment paymentsFragment;
```

```
private Fragment currentFragment;

private ManagerComponent component;

private Toolbar toolbar;
private BottomNavigationView bottomNavigationView;

@Override
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    component = ((MyApplication)
        getApplication()).getComponent();
    component.inject(this);

    fragmentManager = getFragmentManager();
    loginFragment = new LoginFragment();
    component.inject(loginFragment);
    splashFragment = new SplashFragment();
    component.inject(splashFragment);
    accountsFragment = new AccountFragment();
    component.inject(accountsFragment);
    offersFragment = new OffersFragment();
    component.inject(offersFragment);
    graphicFragment = new GraphicFragment();
    component.inject(graphicFragment);
    paymentsFragment = new PaymentsFragment();
    component.inject(paymentsFragment);

    bottomNavigationView = (BottomNavigationView)
            findViewById(R.id.bottom_navigation);

    toolbar = (Toolbar) findViewById(R.id.appbar);
    setSupportActionBar(toolbar);

    //Add the Splash homescreen on opening
    currentFragment = loginFragment;
    bottomNavigationView.setVisibility(View.INVISIBLE);
    toolbar.setVisibility(View.INVISIBLE);

    fragmentManager.beginTransaction()
            .add(R.id.content_frame, currentFragment)
            .commit();

    bottomNavigationView.setOnNavigationItemSelectedListener(
            item -> {
                switch (item.getItemId()) {
                    case R.id.action_splash:
                        currentFragment =
                            splashFragment;
                        break;

                    case R.id.action_accounts:
                        currentFragment =
                            accountsFragment;
                        break;

                    case R.id.action_offers:
                        currentFragment =
                            offersFragment;
                        break;
                }
                fragmentManager.beginTransaction()
                        .replace(R.id.content_frame,
                            currentFragment)
                        .commit();
                return false;
            });
}

@Override
public void onLogout() {
    bottomNavigationView.setVisibility(View.INVISIBLE);
    toolbar.setVisibility(View.INVISIBLE);

    fragmentManager.beginTransaction()
            .replace(R.id.content_frame,
                loginFragment)
            .commit();
}

@Override
public void onCloseGraphic() {
    fragmentManager.beginTransaction()
            .replace(R.id.content_frame,
                currentFragment)
            .commit();
}
```

```
@Override
public void onEnlargeGraphic(GraphicItem
    graphicItem) {
    graphicFragment.setGraphic(graphicItem);

    fragmentManager.beginTransaction()
            .replace(R.id.content_frame,
                graphicFragment)
            .addToBackStack("tag")
            .commit();
}

@Override
public void onOpenTransactions(GraphicItem
    graphicItem) {
    graphicFragment.setGraphic(graphicItem);

    fragmentManager.beginTransaction()
            .replace(R.id.content_frame,
                graphicFragment)
            .addToBackStack("tag")
            .commit();
}

@Override
public void onOpenPayments(Account selectedAccount) {
    paymentsFragment.setSelectedAccount(selectedAccount);

    fragmentManager.beginTransaction()
            .replace(R.id.content_frame,
                paymentsFragment)
            .addToBackStack("tag")
            .commit();
}

@Override
public void onLogin() {
    currentFragment = splashFragment;
    bottomNavigationView.setVisibility(View.VISIBLE);
    toolbar.setVisibility(View.VISIBLE);

    fragmentManager.beginTransaction()
            .replace(R.id.content_frame,
                currentFragment)
            .commit();
}

@Override
public void onClosePayments() {
    accountsFragment.refreshAccounts();
    fragmentManager.beginTransaction()
            .replace(R.id.content_frame,
                currentFragment)
            .commit();
}

@Override
public void onBackStackChanged() {
    if(fragmentManager.getBackStackEntryCount() > 0)
        {
        fragmentManager.popBackStackImmediate();
    }
}
```

E.2 Layout Files

An example of the XML files comprising the layout of the screens in the Android application.

E.2.1 File: AndroidManifest.xml

```
<?xml version="1.0" encoding="utf-8"?>
<manifest
    xmlns:android="http://schemas.android.com/apk/res/android"
    package="barber.psdbank">

    <application
        android:name=".MyApplication"
        android:allowBackup="true"
        android:icon="@mipmap/ic_launcher"
        android:label="@string/app_name"
        android:supportsRtl="true"
        android:screenOrientation="portrait"
        android:theme="@style/Theme.AppCompat.Light.NoActionBar">
        <activity android:name=".MainActivity">
            <intent-filter>
                <action
                    android:name="android.intent.action.MAIN"
                    />
                <category
                    android:name="android.intent.category.LAUNCHER"
                    />
            </intent-filter>
        </activity>
    </application>

    //For google maps use
        <uses-permission
            android:name="android.permission.ACCESS_FINE_LOCATION"/>

</manifest>
```

E.2.2 File: activitymain.xml

```
<?xml version="1.0" encoding="utf-8"?>
<RelativeLayout
    xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:app="http://schemas.android.com/apk/res-auto"
    android:layout_width="match_parent"
    android:layout_height="match_parent">

    <android.support.v7.widget.Toolbar
        android:id="@+id/appbar"
        android:layout_width="match_parent"
        android:layout_height="?attr/actionBarSize"
        app:itemBackground="@color/colorPrimary"
        app:itemIconTint="@color/white"
        app:itemTextColor="@color/white"
        app:popupTheme="@style/ThemeOverlay.AppCompat.Light"
        android:elevation="4dp"
        android:theme="@style/ThemeOverlay.AppCompat.ActionBar"
        android:background="?attr/colorPrimary"
        app:menu="@menu/appbar" />

    <android.support.design.widget.BottomNavigationView
        android:id="@+id/bottom_navigation"
        android:layout_width="match_parent"
        android:layout_height="?attr/actionBarSize"
        android:layout_alignParentBottom="true"
        app:itemBackground="@color/colorPrimary"
        app:itemIconTint="@color/white"
        app:itemTextColor="@color/white"
        app:menu="@menu/bottom_navigation_main" />

    <FrameLayout
        android:id="@+id/content_frame"
        android:layout_width="match_parent"
        android:layout_height="match_parent"
        android:layout_below="@id/appbar"
        android:layout_above="@id/bottom_navigation"/>


</RelativeLayout>
```

Appendix F

Paper Submissions

Details for the two papers being written using the findings of this dissertation work. One concentrates on the creation and use of the new SITAM acceptance model whilst the other summarises the potential effects of PSD2 and the level of approval for the proposed new multi-bank application.

F.1 CHI 2018

Title

Integration of Innovation Diffusion Theory with technology acceptance modelling to inform system design throughout a project life cycle.

Submission Details

Paper submission to ACM CHI 2018 subcommittees *Engineering Interactive Systems and Technologies* and *Understanding People: Theory, Concepts, Methods.*

Abstract

Technology acceptance modelling has long been utilised to offer an estimation of the possible user uptake of new systems prior to release. However, no existing models have successfully encompassed analysis of the type of participants being surveyed to subsequently guide development towards the target market.

To address this, a newly extended adaption of the Technology Acceptance Model (TAM) has been created with aspects of Innovation Diffusion Theory (IDT). This collects an acceptance

value whilst also providing a new way to estimate survey participants level of innovation, adding an aspect of Social Intention to create the SITAM. This was then used in the development of a new mobile finance application to determine the validity of creating distinct system designs aimed at users at different levels of the IDT innovation scale.

F.2 Deutsche Bundesbank Conference

Title

How PSD2 could improve user interactions with personal finance and lead to a FinTech revolution within the mobile banking market.

Submission Details

Deutsche Bundesbank Conference on The Future of Financial Intermediation: Opportunities and Challenges Posed by Regulatory Reforms and New Technologies (November 2017).

Paper will be submitted under the advertised brackets of *the impact of regulation on competition among banks and other financial institutions* and *the market entrance and exit of traditional financial institutions and fintechs.*

Abstract

Payment Services Directive II promises to provide a consistent regulatory standard for payment providers across the EU upon its upcoming enactment. Of particular interest are the so called 'access to account' XS2A articles found within the PSD2 revision that will require regulated payment service providers to allow third parties to access and perform actions on customer accounts. This provides a whole range of potential ways for FinTech firms to enter the mobile banking market and take business from the large financial establishments, providing the foundations for the first trustworthy and regulated account aggregation applications.

The paper considers this previously academically unexplored area by creating and analysing the potential uptake of a new mobile banking application that accepts multiple accounts from any PSD2-compliant providers. It then extracts the spending habits from these and works with price comparison services to offer customers accurate financial advice and offers.